TEACHERS' MANUAL
AND KEY

FOR CURTIS, CALDWELL, AND SHERMAN'S

EVERYDAY BIOLOGY

AND

WORKBOOK AND TESTS

TO ACCOMPANY *EVERYDAY BIOLOGY*

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TEACHERS' MANUAL AND KEY

THE AIMS OF EVERYDAY BIOLOGY

In Everyday Biology the authors have recognized certain outstanding or major objectives. These are

(1) to develop understanding of fundamental principles of biology to the end that these may contribute optimally to the development of broad interpretive understandings, such as those of health, conservation, and the like;

(2) to provide abundant and guided training in scientific attitudes and in the use of scientific method;

(3) to develop useful and interesting acquaintance with living things;

(4) to provide abundant biological materials of wide variety for leisure and recreational purposes.

Mastering the major generalizations of science and acquiring scientific attitudes are the two major objectives of a science course for secondary schools accepted by the Committee on the Teaching of Science appointed by the National Society for the Study of Education.[1] The vertical organization of subject matter and principles in such a way that they will contribute to the growth of broad interpretive understandings is a major objective in the program of the Committee on Science of the Progressive Education Association.[2] The worthy use of leisure, one of the seven objectives of secondary education stated in the Cardinal Principles of Education,[3] is included along with other specific purposes of high-school biology in the summary of judgments of college teachers of biology who had previously taught in secondary schools.[4]

The materials of instruction in Everyday Biology have been planned, organized, and refined through extensive classroom trial in order to afford cumulative progress toward the attainment of these major goals of science teaching.

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[1] "A Program for Science Teaching," The Thirty-first Yearbook of the National Society for the Study of Education, Part I, Chap. IV. Public School Publishing Co., Bloomington, Illinois, 1932.

[2] Science in General Education, the Report of the Committee on Science Instruction of the Progressive Education Association. D. Appleton-Century Company, Inc., New York, 1938.

[3] Cardinal Principles of Secondary Education, Bureau of Education Bulletin, 1918, No. 35, p. 32. Government Printing Office, Washington, D.C.

[4] Otis W. Caldwell and Florence Weller, "High School Biology Content as Judged by Thirty College Biologists," School Science and Mathematics, Vol. XXXII (April, 1932), pp. 411-424.

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A DISCUSSION OF THESE AIMS

The Teaching of Scientific Principles. Until recent times the attention of classroom teachers of science has been too largely focused upon the teaching of scientific facts. The teacher's success has been measured usually in terms of the amount of factual information which his pupils have been able to reproduce in examinations. Thoughtful and conscientious teachers, however, have been surprised at the rapidity with which pupils subsequently forgot many of the facts which they were supposed to have learned. Attention is now focused upon the attainable objectives of science teaching. It is now realized that effecting the retention of purely factual information does not constitute the major goal of science instruction. No one believes, however, that the objectives can be attained without use of factual materials. The necessity for learning facts in courses in science is not questioned. All the desired goals of any science course must be based upon facts which are or have been determined by experimentation and observation. But it must be recognized that if science courses are to function in the fullest way, their requirements cannot be satisfied by mere cramming of scientific facts. The authors of this book, therefore, have based the materials and methods upon the conclusion that the acquiring of facts by the pupils, though necessary, should serve not as the end of the course but as the means of achieving more important goals. One of these desired goals is the functional understanding of scientific principles.

A principle is defined as a generalization based upon many observed facts. For example, a scientist may observe that young partridges when quiet are difficult to see, even though in plain view (p. 272); that a bird on her nest resembles the background to an extent that may keep her presence undetected (figure, p. 60); that an insect may look like the leaf of the twig upon which it alights (figure, B, p. 199); etc. Finally as a result of these various observations the scientist arrives at some such generalization as "Certain animals have body colorations which blend with the habitat, making them almost invisible and therefore improving their chances for escape from enemies." Such a conclusion is the statement of a principle -- in this case the principle of protective coloration. As the pupil's knowledge of science broadens and deepens, he finally learns to combine minor principles, generalized from a limited field of observation or study, with other minor principles into larger principles or major generalizations. A major aim of Everyday Biology is to present biological facts in such a way as to make certain that pupils will arrive at an understanding of principles. An understanding of a principle has become functional when the pupil has mastered its meaning to such an extent that he can apply it in interpreting new observations and experiences in everyday life. For example, one of the authors recently observed a pupil looking for something in the grass. When he asked her what she was seeking, she replied: "My beetle. I dropped it here, and its protective coloration is so good that I can't find it." This pupil had achieved a functional understanding of the principle of protective coloration.

There is considerable research evidence that clearly indicates that a principle which has been firmly established in the mind of a pupil is likely to be retained after the pupil may have forgotten the separate facts or observations which he used as he generalized and stated the principle. The facts of science may therefore be likened somewhat to the materials out of which the scaffolding

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and the walls of a building - the principles - are built. The scaffolding is indispensable, as are the materials of the walls of the building. But once the walls have been firmly constructed, the materials of the scaffolding are no longer essential, and the building is not affected when they are removed. A functional understanding of biological principles provides the logical basis for ensuring the cumulative growth of such interpretive understandings as nutrition, health, conservation of living things, and improvement of the race and of its living environment.

The Development of Scientific Attitudes. The scientific attitudes are stated on pages 624-625. The extent to which teachers of science are successful in establishing the scientific attitudes is one measure of the extent to which the coming generation will be emancipated from superstition, gullibility, provincialism, intolerance, the tendency to make snap judgments, and the tendency to heed absurd or false propaganda.

There is considerable research evidence which strongly indicates that scientific attitudes are likely to be developed to a satisfactory extent only if they are taught definitely, specifically, and repeatedly. Therefore in *Everyday Biology* the materials for developing scientific attitudes are numerous and varied and are distributed throughout the book.

The Teaching of Scientific Method. Closely allied to the scientific attitudes are the various elements of scientific method, that is, the methods invented and followed by the world's greatest scientists in their tireless search for truth. Elements of scientific method are stated on page 625. Like the scientific attitudes, the elements of scientific method can be taught successfully only by means of direct and repeated applications of them. Accordingly, numerous applications to make their meaning and use clear, by careful explanation, by illustration, and by abundant drill, are included with various experiments and exercises.

Useful and Interesting Acquaintance with Living Things. A characteristic of an inquiring mind is its effort to learn about the phenomena which occur in the environment. The living things composing the biological environment are almost unlimited in number and in their significance to men. Most human industries depend in one way or another upon plant or animal life. Artificial plantings indoors and out of doors, as well as natural landscapes, have important places in aesthetics. Even man's health is constantly affected by his relation to other living things. For these and other reasons educated people include biology in their fields of learning.

Training for the "Worthy Use of Leisure." With the increasing emphasis upon the necessity that each subject studied in school shall contribute to the equipment of pupils for enjoyment of worthy leisure activities, it is essential that the course in biology be constructed so that it may contribute in the best way to this desired objective. The book is therefore abundantly supplied with devices designed to encourage the study of biology as a leisure enjoyment. Such devices include projects, special reports, reading lists of fascinating books of science, "vacation-time biology," and an extensive section (pp. 628-653) devoted to biological hobbies and activities in wide variety.

GENERAL SUGGESTIONS TO TEACHERS

1. The Plan of the Book. Everyday Biology has a simple organization consisting of eight major units. Chapter I, which precedes Unit I, serves as an introduction to the course.

Each unit opens with a two-page "preview" intended to capture the interest of the pupils, to focus it upon the unit, and to orient the pupils by presenting the major problems which the unit discusses. The unit is organized in chapters, each of which is further divided into sections of convenient length for day-to-day assignments.

2. Opening Questions. At the beginning of each chapter (except Chapter I) there is a group of questions under the heading "Questions This Chapter Answers." This group includes only a part of the important points with which the chapter deals, but does indicate the principal topics which the chapter discusses. Preceding the assignment or study of each chapter, it is desirable to have the class read the "Questions This Chapter Answers." By commenting briefly upon the questions the teacher may help the pupils to gain the proper perspective for the materials included in the chapter.

These opening questions may also be used as the basis for subsequent drill and review. Only the best pupils are likely to be fully prepared to discuss all the questions after having studied the chapter. All pupils, however, should be prepared to answer at least those questions which are based upon the starred paragraphs in the text. (See the note "To the Teacher," p. 5.)

3. Graded Materials. It is hardly likely and is not expected that any pupil will master all the material in the textbook. Each one should, however, read all the material, and each should master an amount appropriate to his ability. Every pupil should acquire a knowledge of the nature and meaning of at least the starred topics.

4. The Proper Use of Experiments. Throughout the textbook are numerous experiments. It will be noted that these in all cases precede the text discussion of the facts or principles revealed by the experiments. This plan of presenting the laboratory activities is in line with the best modern practices in developing and retaining pupil interest and in giving effective training in the elements of scientific method. A laboratory exercise should be performed before the material explaining the exercise is studied by the pupils because an experiment is a relatively purposeless and futile device unless it provides a means for solving some problem the answer to which the pupil does not already know. The older practice of introducing experiments solely or chiefly as a means by which pupils may verify facts and principles already known to them is sterile and indefensible. The practice exemplified in Everyday Biology, the inductive method, stimulates and retains the pupil's interest because he does not know what the result of the experiment will be. Therefore it provides the optimal means by which to teach scientific method and scientific attitudes (see pages 624 and 625).

After an experiment has been performed, the study of the text, together with class or group discussions, provides means of supplementing and clarifying the concepts established by the experiment.

It is not expected that any pupil or any class will perform all the experiments. A large number are included in the text and in the accompanying workbook in order to afford a sufficiently wide selection to provide optimally for individual differences. Pupils should be given the opportunity to perform experiments individually, but it is neither necessary nor desirable for them to perform all experiments individually. Many experiments may profitably be presented as demonstrations by the teacher.

Following many of the directions for experiments are one or more questions directing the pupil's attention to specific elements of scientific method which are especially well illustrated by the activities of the experiment. By a discussion of these questions valuable training and drill in the repeated use of scientific method are assured.

5. Motion-picture Films. At the end of each unit is a limited list of motion-picture films. These lists are suggestive of the types of films that are readily obtainable from the extension divisions of most of the great universities and colleges at no cost to schools except the expressing or mailing charges. New films are constantly being made available by the different companies selling or renting motion-picture films.

Used in the least effective ways, motion pictures shown in connection with work in science may serve merely as effortless entertainment for the pupils, with little or no positive values. Used in the best ways, motion pictures may serve as valuable aids to instruction. Among the best practices in the use of motion-pictures as supplementary aids to instruction are these: (1) Show only those films which actually supplement the materials developed through the other activities of the classroom and introduce the films only at times when they best serve to amplify, supplement, and make clear the materials which are being studied. To show the film at whatever time it becomes available, without reference to its relation to the material then under discussion, renders it both ineffective and even in some cases detrimental because it is distractive and confusing. (2) Precede the showing of a film with a brief statement of its nature and its expected contribution to the discussion in hand. (3) Before its showing, present the pupils with a short list of important questions the answers to which will be found in a careful viewing of the film. (4) During the showing of the film, stop the film, if possible, at important points for discussions of the significance of what has been seen. (5) Follow the showing of the film with a discussion of the questions previously prepared for use with the film, in order to locate points which still remain obscure in the pupils' minds. (6) Show the film a second time, in order to clear up the difficulties discovered during the previous discussion. (7) Follow this final showing of the film with a short test covering the important points brought out by the film. (8) Conduct a class discussion of the film in which the contributions of the film to the units and activities in progress are made clear.

6. Use of the Glossary. The glossary of a textbook is of great importance as a teaching device. It serves as a convenient "dictionary" for ready reference

by the pupil, and it provides an excellent means by which to review important terms and concepts. To be maximally effective a glossary should provide several specific pupil aids: (1) a simple and easily understood method of pronouncing all the terms; (2) a designation of the most important terms from among the many included in the entire glossary; and (3) a close connection between the terms pronounced and defined and the text material of the book.

The Glossary of Everyday Biology accomplishes the first of these functions by means of a few simple and readily understood pronunciation symbols. It accomplishes the second by the introduction of asterisks before the biological terms found to be most important as the result of extensive research.[1] It accomplishes the last by introducing along with the definition of each term a reference to a point in the text where the term is used in a way that makes its meaning clear.

The study of the meaning of a word out of context is usually more or less ineffective. It is therefore suggested that the pupils be encouraged to follow the practice of reading the text reference whenever they study the definition of a word in the Glossary. By studying or reviewing the definition as given in the Glossary along with the connotation of the term in the passage cited, the pupil strengthens and multiplies the "bonds" by which he may subsequently recall the term and its meaning. The use of the Glossary in the way just indicated is one certain means of promoting mastery of important biological terms.

7. Order of Units. The order of units in the textbook was determined by the results of extensive experience in teaching general biology to high-school pupils. For purposes of review and drill, moreover, numerous references to topics developed in earlier units and applications of materials previously discussed are introduced into later units. That is, the organization in the textbook is cumulative and progressive. For the best results in using the textbook in most situations it is suggested, therefore, that the units be studied in the order in which they appear.

8. Illustrations. The illustrations and their legends are designed as organic and necessary parts of the teaching materials and should be so used. They provide a visual basis for an understanding of topics discussed in the text. Encourage the pupils to examine carefully each illustration at the point where it appears in the text. Have the pupils read and discuss the legends under the illustrations. Some of these legends supply additional factual material not given in the text; nearly all introduce thought questions. These questions are of many different types and of varying grades of difficulty. These should lead the pupil to make practical applications of the facts he has learned. Some of the legends contain suggestions for special reports or for projects or include "Self-tests on Biological Principles." Every picture has a definite and important part in developing a functional understanding and appreciation of biology.

9. Self-tests. There is a "Self-test" at the end of each section in each chapter. These tests are intended for the use of each pupil in determining whether he has mastered the materials presented in the problem. Some of these tests involve only a knowledge of facts; others test the ability of the pupil to use the facts as a basis of reasoning. If after studying the problem a pupil is

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[1] Francis D. Curtis, Investigations of Vocabulary in Textbooks of Science for Secondary Schools. Ginn and Company, Boston, 1938.

unable to answer the test items correctly, he should carefully review the materials. These items, with the "Questions This Chapter Answers," should later serve as an effective means of review.

As a further part of the testing plan designed to cover all the materials in Everyday Biology a test book has been prepared to accompany the workbook. This includes a test upon each of the units; sets of examinations covering the entire textbook; a test on structures and functions; and special tests on scientific attitudes, on scientific method, on biological principles, and on social implications. Each unit test and the midyear examination have two parts. Part I tests both the pupil's knowledge of important facts and his ability to apply these facts in problem situations. Part II tests his ability to reason scientifically and to use scientific method and scientific attitudes. The final examination of one hundred items and the several special tests which follow it may together be considered as means of measuring achievement in the major goals of the course at the end of the year.

At the ends of most of the chapters "Self-tests on Biological Principles" will be found. These are intended to focus attention upon one of the major objectives of the course. It will be found profitable to use these as the basis for class discussions, especially to stimulate the abler pupils. Here and there throughout the book are "Self-tests on Organization of Facts." These are intended to aid the pupil in summarizing and organizing for himself the important facts covered in the preceding pages.

10. Problems. In addition to the questions and problems found in the legends of the illustrations, there is a section of problems at the end of every chapter except the first. These constitute a part of the plan to provide for individual differences. The answers to these problems, as well as to those under the illustrations, will be found arranged by chapters in this Teachers' Manual.

11. Special Reports. Special reports constitute another part of the plan for adjusting the work to individual differences in interest, aptitude, and ability. These topics may be assigned to pupils or may be selected by them to be studied in such reference books as are available. They may be presented as written reports or may serve as the basis for oral composition in the form of oral reports to the whole class.

The special reports, with the questions and problems, will facilitate teaching by the individual or contract plan whenever it may be desired to use that plan. They cover a wide range of material and may often be made the basis for co-operative teaching by the teacher of science and the librarian or the teachers of English, history, or industrial arts.

12. Projects. These constitute still another part of the plan to provide for individual differences. They are not intended as tasks to be assigned but are planned as challenges to the interest, ambition, and ingenuity of the pupil. It will be found stimulating if a growing permanent school exhibit be developed from year to year, presenting the results of work on projects.

13. Learning New Words. The vocabulary of this book has been made extremely simple in order to ensure its comprehension by all the pupils. Also, the text has been planned and written so as to ensure that every pupil shall add to the

number of useful words which he can sense, spell, and use correctly. To promote this definite vocabulary-building, words likely to cause difficulty are pronounced and defined at the bottom of the page upon which each first appears; also, these words are used later in the book sufficiently often to provide drill in their proper use. To facilitate this vocabulary drill still further, scientific terms are listed and defined in the Glossary. With each term there defined a reference is made to a page where that term is used and where additional information about it is given. Thus it will greatly facilitate the pupil's mastery of these new terms if he will re-read the page referred to, in order to see again how the word was used.

To ensure a thorough understanding of the most important terminology of biology, a "Self-test on Important Biological Terms" is included at the ends of chapters.

14. Training in Scientific Attitudes. There are frequent exercises on scientific attitudes at the ends of experiments and at the ends of chapters. Often these exercises are based upon important incidents in the history of biology.

These exercises are not intended to be assigned but are intended to stimulate thinking and to serve as drill upon the scientific attitudes. They can profitably be made the basis for stimulating class discussions which the pupils will find both enjoyable and profitable. The pupils will sometimes wish to prepare added exercises of a similar nature. There are many superstitions and other unfounded beliefs that may be made the basis for pupils' added exercises.

15. Training in Scientific Method. Many of the experiments included in the text are accompanied by exercises on one or more elements of scientific method. These should be discussed as a desirable if not essential part of the experiment. These exercises are all "keyed" in this Teachers' Manual.

16. Emphasizing the Social Aspects of Biology. Throughout the book are numerous discussions of "social implications" of facts and principles of biology. In addition, special exercises on "Social Implications of Biological Principles" are sometimes included at the ends of chapters.

17. Reference Books. A list of reference books supplementing the materials discussed is added at the end of Chapter I and of every unit. In addition to these lists is an extensive bibliography of books (pp. 650-651) which have been found to possess unusual appeal to pupils as books to be read for recreation.

18. Questions for Debate. Questions for Debate will be found at the ends of some chapters. They provide an effective type of activity, both for the classroom and for the school-assembly program.

SUGGESTIONS FOR THE FIRST DAY'S WORK

Chief Chapter Objectives. (1) To give a brief introduction in which answers are given to certain questions which many pupils ask about biology; (2) to arouse new interests and motivate later study of biology.

The importance of the first day's work is sometimes overlooked. With at least part of the pupils the success of the biology course depends on the first impressions which they gain. When beginning any new subject, pupils are usually eager to learn what it is about and what are the kinds of materials included in it. The first meeting of the class, therefore, should give the pupils a general view of the course as a whole. This will provide satisfying and stimulating perspective and will prevent the confusion and discouragement which result when pupils are plunged blindly into details without proper orientation.

Begin the first period by asking pupils to turn to Chapter I, p. 3. Call attention to the colored plate facing page 3. This picture emphasizes at the start one of the most important interpretive understandings of a modern course in biology, namely, the importance of outdoor recreation as a means of promoting mental and physical health.

Next turn the page to the General Sherman tree. Tell the pupils that the smaller inset pictures represent important events in history which occurred during the life of the tree. Read the legend aloud. Ask the question at the end of the legend; and if there seems to be keen interest in it, ask the class to assist in answering it. Do not attempt to "make exact mathematics" of this problem, since its purpose is to give a general idea. Consider that about four hundred years have elapsed since Columbus's voyage; then put on the blackboard the fraction $\frac{400}{4000} = \frac{1}{10}$, and make clear the fact that all the history of North America since Columbus's voyage occupies only about one tenth of the time this tree has lived. A little added time may well be used in asking pupils to suggest other ways of showing how old this tree really is.

Pause on page 5 to call attention to the various branches of biology. Explain to the pupils that this list is not intended to be learned but is added for their information and to serve for reference purposes.

Continue the reading as before, calling attention to the illustrations. Help the pupils to solve the problems in the legends by supplementing their answers with points such as those given in the answers to these questions in this Teachers' Manual, p. 13. After the pupils have read to the middle of page 8, turn to the Contents, to give them a general impression of the scope of the whole course. Read orally or have the pupils find and read the titles of the eight units. Turn again to the beginning of the Contents and call attention to the chapter headings, one by one, through the eight units. Turn then to the last illustration in the book, p. 654, and encourage a brief discussion of its implications. Next turn again to page 8 and continue oral reading of the rest of the chapter, beginning with "Biology and daily living." This section introduces in an informal way the all-important scientific attitudes, elements of scientific method, and biological principles. Turn to the lists of scientific attitudes and elements of scientific method on pages 624 and 625. State that there will be many times during the course when the pupils will be asked to refer to these attitudes. It is best not to refer to the list of biological principles on pages 626-627 at this time lest the pupils infer that they are to memorize these statements at the start.

If possible, time the first day's work so that at the close you can read "Vacation-Time Biology", p. 11.

Tell the class that during the second class meeting they will discuss the section "To the Student," pp. ix-xi, and that those who wish may look it through before the next meeting. It is best not to assign this section in such a way as to make the pupils think they must memorize any part of it.

SUGGESTIONS FOR THE USE OF THE SECTION "TO THE STUDENT"

Work on this section about how to study should be taken up on the day following the introduction period, just described. It will probably prove most effective for the pupils to go over this section, point by point, with the teacher illustrating the various techniques. Examples are included to make the more difficult techniques clear to the pupils. It will then be a good plan to have the pupils study Chapter II in class in connection with the section on how to study, so that they may be guided and trained in effective study habits. The pupils should then be encouraged to make constant use of the techniques, which should frequently be illustrated in class. Only by repeated correct practice can pupils master the techniques of effective study and develop effective study habits.

APPARATUS[1] NEEDED FOR THE EXPERIMENTS IN EVERYDAY BIOLOGY AND ITS WORKBOOK

General Equipment and Apparatus[2]

1 projection lantern, which can be used both for slides and for pictures and diagrams in books
1 or more aquaria
1 or more Bunsen burners or other heating units
Several large jars, such as battery jars, for small aquaria
1 high-grade microscope for demonstration purposes
1 scales, balance type   10 test-tube holders   2 test-tube racks

Apparatus for Demonstrations or for Pupil Use

	For Demonstration	For Individual Work in a Class of 10
Beakers -- 100 cc.	2	10
Beakers -- 250 cc.	2	10
Beakers -- 500 cc.	1	5
Bell jars -- 10"	2	4
Bell jar -- open at both ends	1	1
Cork-borer	1	1
Cotton	1 roll	1 roll
Cover glasses, microscope	½ oz.	½ oz.
Dissecting sets		
scissors	1	10
scalpel	1	10
needles	2	20
forceps	1	10
Filter paper	1 pkg.	1 pkg.
Flasks -- 250 cc.	1	10
Funnel, glass, 3"	2	4
Glass plate, 5" square	2	10
Glass stirring rod	1	5
Hand lenses or magnifying glasses	5	10
Insect nets	1	5
Knife	1	5
Lens paper	1 pkg.	1 pkg.
Medicine-droppers	2	10
Microscope slides	½ gross	½ gross
Nails, small	--	1 lb.
Needles	1 pkg.	1 pkg.
Netting, mosquito	1 yd.	--
Osmosis membrane (or pig's bladder)	2	10
Petri dishes, 75 mm.	6	1 doz.
Pins	1 paper	2 papers
Razor blades	1 pkg.	1 pkg.
Ring stand and rings	2	10
Rubber bands, assorted	1 box	1 box
Rubber stoppers, 1-hole and 2-hole, assorted sizes to fit test tubes and bottles	2 of each	1 lb. assorted
Sandpaper	1 sheet	2 sheets
Sheet rubber, about 18" square	1	--
Tape, gummed	1 roll	1 roll
Test tubes, 6"	1 doz.	3 doz.
Thistle tube	3	10
Tubing, glass	3 ft.	10 ft.
Tubing, rubber	2 ft.	6 ft.
Watch glass, Syracuse	½ doz.	1 doz.

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[1] The apparatus for the section "Biology for Leisure Time" at the end of the textbook is not included.

[2] Because of constantly changing prices and differences in quality it is impossible to include reliable cost estimates on these items. It is suggested that purchases be made only through dealers of established reliability.

Chemicals and Other Materials	Amount Needed if Experiments are Demonstrated	Amount Needed for Each 10 Students
Agar-agar	2 oz.	¼ lb.
Alcohol	1 pt.	2 qt.
Ammonium hydroxide	2 oz.	4 oz.
Beef extract	2 oz.	2 oz.
Diastase	1 oz.	4 oz.
Eosin (or red ink)	1 oz.	1 oz.
Ether	1 lb.	1 lb.
Fehling solutions A and B	4 oz. each	8 oz. each
Formaldehyde, for preserving	1 gal.	1 gal.
Glucose, or dextrose	1 oz.	2 oz.
Hydrochloric acid	4 oz.	4 oz.
Iodine solution or crystals	1 oz.	2 oz.
Limewater	4 oz.	1 pt.
Manganese dioxide	1 oz.	4 oz.
Nitric acid	4 oz.	4 oz.
Oil, such as olive oil or corn oil	4 oz.	8 oz.
Pancreatin	1 oz.	1 oz.
Paraffin	1 lb.	1 lb.
Pepsin	1 oz.	1 oz.
Phosphorus, red	1 oz.	1 oz.
Potassium chlorate	4 oz.	4 oz.
Soda (baking)	1 pkg.	1 pkg.
Starch	small pkg.	small pkg.
Sugar	½ lb.	1 lb.
Vinegar	1 pt.	1 pt.

Live Materials

In many communities it will be possible to collect the live material needed and to preserve material for later use.

Live material	Amount
Amoeba culture	sold in amounts sufficient for 10-25 pupils
Paramecium culture	
Hydra culture	
Planaria culture	

Crayfish -- 1 for each 2 pupils
Frogs -- 1 for each 2 pupils
Other live materials, such as grasshoppers, earthworms, and moss, can usually be collected locally.

Preserved or Dried Materials

Seeds

Seeds	Amount
bean	1 pkg. of each for 10 pupils
corn	
pea	
mustard	

Crayfish -- 1 for each pupil
Earthworms -- 1 for each pupil
Frogs -- 1 for each pupil
Fish -- 4 for demonstration or 1 for each pupil
Bath sponge -- 1 for each 4 pupils

Microscope Slides

The following microscope slides are desirable:

- Cross section of leaf
- Cross sections of typical monocot and dicot stems
- Longitudinal section of *Hydra*
- Conjugation of *Spirogyra*
- Conjugation of *Paramecium*
- Mitosis in onion root tip

COMMENTS BY UNITS, CHAPTERS, AND PAGES

Chapter I

Figure, p. 4. About one fourth of its life.

Figure, p. 6. By reconstructions of skeletons found preserved in tar pits.

Figure, p. 8. Those scientists lacked attitudes 3 and 7, p. 624.

Figure, p. 9. One cannot state as a major principle, "All animals eat foods that grow on trees," because not all kinds of animals are shown. Other minor principles may be such as "Many animals have mouths which enable them to eat" and "Many plants produce fruits."

Self-test on Biological Principles, p. 10. The statement is true because, if an organism cannot manage to keep alive, it cannot carry on any other activity or solve any others of its problems.

Exercises on Scientific Attitudes, p. 10. 1. The attitudes numbered 1, 8, 9, 11, and possibly 7 (p. 624) were used by primitive men. 2. Best answers are (1) No. 3; (2) No. 9; (3) Nos. 3 and 8; (4) Nos. 3, 8, 9, and 13; (5) No. 4; (6) No. 2; (7) Nos. 3 and 7. 3. No. 5.

UNIT I

Unit Objectives: (1) To present interesting and useful fundamental facts of biology and to show their relationships to certain important biological principles. (2) To develop understanding of scientific attitudes and the scientific method through many applications, examples, and illustrations.

Chapter II

Figure, p. 15. They need to solve the problems of securing food, keeping warm, and finding or making shelter.

Experiment 1, p. 16. Probably the seeds in the second and third pots will have started to grow. Those kept at room temperature will grow best. Check experiment: Fill two flowerpots with sawdust or very dry dirt. Plant in each an equal number of bean seeds, corn grains, or other seeds. Water one flowerpot daily, but add no water to the other.

Experiment 2, p. 16. The glowing splint bursts into flame when thrust into the bottle of oxygen. Oxygen itself will not burn, but aids other substances to burn.

Figure, p. 17. The water-filled bottles contain no air. Therefore when the oxygen displaces the water, the bottles can contain only oxygen.

Figure, p. 18. Where water is abundant, there are many plants; in desert regions where water is scarce, there are few plants.

Figure, p. 19. No green plants can live in the ocean depths because sunlight cannot penetrate there. Therefore animals which feed exclusively on green plants are not found there. Also, because of the enormous pressure, only animals that have become adapted to it can live there.

Self-test, p. 20. 1. (5). 2. Change few to no. 3. Change decrease to increase. 4. Change most to all; change some to all. 5. Change most to all. 6. The animal would probably migrate, though it might become adapted to a scanty water supply.

Figure, p. 21. The centipede lives on land, where it uses its legs to crawl. (Pupils probably will not be able to supply many other facts about its habitat merely from the picture. Someone will probably be interested in looking up further facts about the animal.)

Experiment 3, p. 22. The limewater on the rod becomes milky or cloudy in color. The glowing splint does not burn, but becomes more dim. The lighted splint goes out. Carbon dioxide has no color.

Figure, p. 23. The muskrat house is a shelter for the animals which build it and protects them over winter. The fact that the entrance to the house is under water prevents the entrance of many enemies.

Figure, p. 24. The soil will slowly change to one more suited to evergreens. The decay of leaves and twigs from aspens helps to make conditions that are favorable to evergreens. The evergreens advance into the region now occupied by the aspens, and prove to be more successful competitors for sunlight, and finally shade and kill the aspens.

Figure, p. 26. The prevailing winds blow from the direction at the right of the picture.

Self-test, p. 27. 1. (3); (4); (7); (9); (11). 2. (10). 3. Change symbiosis to parasitism.

Self-test on Biological Principles, p. 27. Any living thing is affected by such factors in the environment as changes in temperature, presence or absence of food and water, and other living things. Any of the examples given in the chapter may be used by the class in illustrating this principle. Living things affect the environment in such ways as the following: (1) a rabbit eats the bark on a tree and kills it; (2) a beaver builds a dam and floods an area of land; (3) birds eat insects which are eating vegetation.

Problems, p. 27. 1. The energy of the sun can be made available for use by man only through the activities of green plants in food-making. 2. Such examples as the following may be suggested: (1) in a very dense forest few smaller plants are found beneath the trees where sunlight does not fall; (2) flies in a room go to the lighted window; (3) owls are more active at night than in the daytime; (4) cockroaches and ground beetles are found in dark crevices. 3. Cats, dogs, horned toads; cacti and other desert plants. Plants growing there would not have long roots to reach deeply into the ground for water or anchorage. They would probably have luxuriant leaves, probably larger than on other plants of their kinds. 4. Examples of artificial shelters are houses or other homes built by man, a beaver hut. Most plants have no shelter of any sort; some of the simpler animals, such as some Protozoa and jellyfish and most fishes, have no shelters. Shelter may enable an animal to conserve heat energy.

Shelter may also enable the animal to conserve energy by preserving its life through protection by the shelter. 5. Pitcher plants and certain orchids grow only in the acid soil of bogs. Sweet potatoes thrive best in sandy soil. 6. In making cities and homes more sanitary, man destroys substances that would serve as food for some kinds of life or would offer shelter to them. For example, rats would find it very difficult to live around a brick apartment building where all garbage and waste materials were placed at once in an incinerator. Other activities which serve to limit life are building cities and dams, mining, causing factory fumes, hunting, etc. 7. Changing environments which affect the life of a region are (1) the flooding of a region because of a landslide which dams up a stream; (2) a drought which kills vegetation, making it impossible for herbivorous animals to survive and finally affecting the animals which prey upon them. 8. The answer to this question will vary greatly for different parts of the country. In general, such animals as the bison, wild turkey, heath hen, snowy egret, and passenger pigeon may be mentioned. Animals that have entirely disappeared from the world in the past few hundred years are the passenger pigeon and the heath hen. 9. The habit of symbiosis aids certain plants and animals to survive by helping to make conditions more favorable. Thus the hydroids growing on a hermit crab's shell are likely to secure more food than if they were growing on a rock; the hermit crab is less likely to be readily seen by enemies when thus camouflaged.

Chapter III

Figure, p. 30. The boy and the dog both show that they are responding to something they have heard or seen or something they expect. They hope to catch fish which may be attracted by the sight of the bait or fly.

Experiment 4, p. 31. The onion-skin cells are oblong in shape. When iodine is added to the slide, the nucleus will show plainly. Probably no structures except nucleus and cell wall can be shown in the drawings, although strands of cytoplasm may sometimes be seen.

The cells from the cheek look much like the epithelial cells shown in the figure on page 35, except that there are not likely to be so many of them clinging together. Pleurococcus cells are small, round, green bodies in which no internal structure can be seen by a beginner. Elodea leaves or young moss leaves will show chloroplasts, and sometimes the student can observe the circulation of protoplasm in such leaves and perhaps can see cytoplasmic threads.

Scientific Method: It was desirable to examine several kinds of cells to learn whether all kinds of cells were alike in their fundamental structure.

Figure, p. 32. Nutrition, growth, reproduction, irritability.

Figure, p. 33. Hooke's work represents scientific attitudes 1, 6, 7, 8, 9, 10, and probably 13.

Figure, p. 34. All living things are made up of one or more cells. All functions performed by living things are carried on by the living cells which compose them.

Self-test, p. 34. 1. (2), (4), (5), (6), (7). 2. Is irritable; can grow and reproduce; must carry on nutrition, respiration, and excretion. 3. 1,f; 2,h;

3,i; 4,a; 5,e; 6,c. 4. Change most to few. 5. R. (The letter R indicates that the statement is correct and needs no change.) 6. Change organs to cells. 7. Change a tissue to an organ.

Figure, p. 35. Alike in that all are made up of protoplasm and that all carry on common life functions. Differ in shape, size, thickness of walls, relations to one another, and in the presence of substances such as food or chloroplasts. Different tissues vary in the purposes they serve.

Figure, p. 37. In general, the ancient plants and animals were larger than related forms living today, though the whale and the sequoia, the largest animal and plant, exist today.

Figure, p. 38. The mother bear has produced cubs, which will grow to resemble the adult. The animals are able to move about; the cubs are showing their responses to their surroundings -- that is, their irritability -- by looking about and by following the mother. Nonliving things do not reproduce, move under their own power, show irritability, or grow.

Figure, p. 39. The gas or oxygen is composed of molecules each of which contains two atoms of the element oxygen. Every atom of oxygen is like every other atom of oxygen, and cannot be broken up into simpler substances. The compound, water, is composed of molecules each of which contains two atoms of hydrogen and one of oxygen. The mixture contains some molecules of water and some of oxygen.

Figure, p. 40. The percentage of the various elements are, approximately, oxygen, 65; carbon, 19; hydrogen, 12; nitrogen, 3; sulfur, 3. Some of the other elements are phosphorus, potassium, calcium, magnesium, and iron.

Figure, p. 41. Organic: dogs, men, and probably the reins, the other parts of the harness, and the sled runners. Inorganic: snow, clouds, and air. Objects composed of protoplasm are the dogs and the men.

Self-test, p. 41. 1. See pages 36 and 38. 2. 1,g; 2,h; 3,f; 4,b; 5,a; 6,a. 3. Elements: iron, lead. Compounds: lean beef, wood. Mixtures: lemonade, smoke, wet sand, air containing much water vapor. 4. Organic: hair, milk, ground-bone fertilizer, a leaf, manure, living dust, wood. Inorganic: gold, marble, nonliving dust, glass.

Figure, p. 43. Physical changes: chopping the tree in the two upper pictures; the skate marks on the ice, water changed to ice, and vapor in the breath condensed into a visible cloud; if the boy in the lower-right picture hits the target, the target will undergo a physical change. Chemical changes: the burning of fuel; cooking meat; explosion of gunpowder.

Figure, p. 44. The semipermeable membrane of the capsule separates the water from the molasses. Both liquids will tend to go through the membrane. For explanation of osmosis see pages 43-45.

Experiment 5, p. 44. Considerable water has entered the capsule, causing it to swell.

Self-test, p. 45. 1. Change respiration to oxidation. 2. R. 3. Change chemical to physical. 4. Change oxidation to osmosis. 5. R.

Self-test on Biological Principles, p. 45. All living things are made up of one or many cells; the life activities of nutrition, respiration, etc. are carried on by every cell.

Problems, p. 45. 1. The cells which compose living things differ somewhat; tissues must be of different kinds because they have different kinds of work to do. 2. A vegetable stew is a mixture because it is composed of pieces of vegetables which are not united to form entirely different substances. Concrete is at first a mixture of sand, cement, and water; as it sets, chemical changes take place which make new compounds, although the concrete is as a whole a mixture. 3. Air over a city will contain more smoke, gasoline fumes, carbon dioxide, and similar substances. 4. Physical changes: roots splitting a tree, water freezing, etc. Chemical changes: a tree stump decaying, food made and stored in seeds, etc. 5. Dried prunes swell more when cooked in water without sugar because the absorption and osmosis of water are more rapid.

Exercises on Scientific Attitudes, p. 45. 1, The attitudes shown by the work of Schleiden and Schwann are chiefly 1, 2, 3, 7, 9, 6. 2. A willingness to accept the sentence on page 33 beginning "The gray matter in the human brain..." illustrates 10 and possibly 11. The second paragraph on page 33 illustrates 7.

Chapter IV

Figure, p. 48. Electrical energy in streetcar; kinetic or mechanical energy of the moving train; heat energy in the steam; mechanical energy of running water, of the wind, of the whirling windmill, and of the moving automobile; kinetic energy of the running dog and the rabbit and of the paddling boys; potential energy of the canoe and water at top of rapids; potential energy (food energy) in the load of watermelons and of the gasoline in the truck and automobile.

Figure, p. 50. The circus animals must have food and air; they must contend with diseases and insect pests. If they were wild, they would find it necessary (1) to secure their own food; (2) to fight enemies which might devour them; and (3) to seek shelter against unfavorable weather.

Figure, p. 52. Energy cycle: There is a limited supply of available energy, and this must be changed from one form to another and used over and over. Virtually all the energy in the world comes from the sun and is transformed into food energy by green plants. This food energy is secured by animals which eat the plants. Thus energy is used repeatedly. So far as we know, it is never returned to the sun. The energy cycle is therefore not so complete as is the matter cycle. Matter cycle: There is a limited amount of matter in the world, and it must be used over and over again. The matter cycle is shown in the figure. The deer have eaten grass to secure food for their growth. The mountain lion kills the deer for his own food. An Indian kills the lion and uses parts of the deer for food. The skeletons of the deer and lion decay, and the material which composed the bones and any remaining flesh goes to form part of the soil. Years later, corn which grows in this soil uses the same material for its growth and to store in its ears. The man uses the corn to feed his hogs, and the matter which composed the grains of corn is used to make flesh of the hogs. The hogs are then butchered, and the meat is delivered to the market to be used as food for man. The energy cycle: The mountain lion kills the deer for the potential energy stored in its flesh. The Indian also uses the potential energy of the deer's flesh. Years later, the sun's energy is changed by the corn plants into potential energy which is stored as food. The hogs eat this stored energy, and, later, man secures his needed energy from the meat of the hog.

Note. The energy cycle cannot be traced as a complete cycle. The sun is the source of most of the energy which is transformed to other forms of energy, but we cannot trace the return of the energy back to the sun.

Figure, p. 53. Bracket toadstool, corn smut, wheat rust, cedar apple.

Figure, p. 54. Leaves make food; roots anchor the plant and secure water; flowers produce seeds; seeds scatter, and produce new plants. The underground stem can live through the winter and grow again in the spring.

Figure, p. 55. In the ovary.

Self-test, p. 56. 1. Sun. 2. Change light to energy. 3. R. 4. R. 5. Change few to no. 6. Change saprophyte to parasite. 7. Change an independent to a dependent. 8. Change dependent to independent. 9. Change simple to complex. 10. Division of labor.

Figure, p. 57. Likenesses: Each part or organ of the horse does some one kind of work, just as each man in a gang of workmen has his own kind of work to do. Differences: One difference is that such organs of the horse as the eye and the leg have become so specialized that they could not exchange jobs, while it would be possible for the man with the wheelbarrow and the man with the pickax to exchange places.

Examples of division of labor in complex organisms are these: (1) A tree has roots which anchor it, branches which hold the leaves, fruits which produce seeds. (2) A man has fingers which enable him to pick up things, legs for locomotion, ears which enable him to hear, etc.

Figure, p. 58. Beaver represents type 3, an enemy which kills its victim at once. The sand represents type 4, since it changes the habitat.

Figure, p. 60. The adaptation of behavior shown is the habit of remaining motionless when a possible enemy approaches.

Self-test, p. 61. 1. See page 58. 2. Change all to many. (The amoeba, for example, has no structures for protection; many one-celled plants, as some of the algae, have none.) 3. (4) food and water (since the others are protective adaptations).

Figure, p. 62. That the thistles are well fitted to compete for energy is shown by the fact that they are growing abundantly and that there are no other plants which might otherwise be growing on the soil. The balance of nature was disturbed when man cleared the land of plants which were naturally growing in this place, and thus an area was provided where thistles can grow abundantly.

Figure, p. 64. Cooper's hawks are undesirable because they often destroy useful birds.

Self-test, p. 65. 1. R. 2. Given on pages 63 and 64. 3. R.

Self-test on Biological Principles, p. 65. 1. Animals are dependent on green plants either directly or indirectly for food and for oxygen. The plants use the carbon dioxide given off by respiration in the animals to make food. Plants also use other wastes given off by the animals. 2. Only a limited number of plants can grow and can secure adequate water and light in a given area. Animals compete with one another for the animals or plants on which they feed. Some animals, in their struggle for energy, eat parts of plants (leaves, seeds, or roots) and thus cut off those plants' energy supply. 3. A plant which has thorns or a bad odor or taste is less likely to be eaten than one without such adaptations. An animal which is protected from enemies is more likely to survive and to have descendants. 4. A tree has roots, stem, leaves, and many other special structures, each having its own definite function which aids the tree to survive. Similar structures are possessed by the cat, dog, and almost every other living thing. 5. In almost any area many different kinds of plants and animals may be found. The animals feed on the plants or on other animals, but very seldom does one kind exterminate another. The plants compete for soil and sunlight, but one species seldom kills off all other kinds.

Figure, p. 66. Because they are not found elsewhere in the world and are valuable for scientific study, as well as because of their interest to many people.

Social Implications of Biological Principles, p. 66. 1. In the home-room certain members serve as president, secretary, and other officers; other members serve on committees. The same kinds of responsibilities are carried out by various members in the other activities, everyone doing his part to make the play successful or to win the game. 2. Many examples may be given of nations which have waged war to secure land or natural resources. The ancient Roman Empire, for example, conquered most of the known world.

Problems, p. 66. 1. Such an example of the energy cycle as the following: The radiant energy of the sun is transformed to food energy in a lettuce plant, which is eaten by a rabbit, which in turn is eaten by a dog. The same story, with attention called to the transfer of matter, illustrates the matter cycle. Division of labor is shown in the robin, which has wings for movement, feet for support, a beak for feeding, eyes for observing food and enemies, and so on. 2. Adaptations are changes in the structures or behavior of the animal itself. A house therefore is not a protective adaptation. 3. No, that particular toad would be dead. 4. To care for domestic animals man must fence off pastures and plant fields. He destroys some plants, and produces other in abundance. He kills wild animals that would prey on his domestic animals. 5. Yes, Robinson Crusoe planted seeds from the ship; he cultivated soil; he killed some of the animals; and so on. 6. Such adaptations as the thick hairy leaves of mullein, which protect it against rapid changes of moisture and temperature; the long roots of desert plants, which enable them to secure water; the shedding of leaves of deciduous trees, which protects them from too great loss of water; the claws of a cat, which aid in food-getting and in protection from enemies. 7. Manufacturing company (4); sparrow (1); big tree (2); hailstorm (3); stream (4); dandelion (2). 8. The chrysalis or cocoon of an insect (1); a growling dog with bared teeth (7); a white ptarmigan in snow (5); the armor of a crocodile (1), (2); a knight in armor (3); the spurs of a rooster (1); a bird flying when another animal approaches (4); the odor that a shrew gives off (6).

UNIT II

Unit Objectives: (1) To learn about ways in which plants manufacture their food materials. (2) To give a comprehension of the principle that the activities of plants make all other life possible. (3) To give additional evidence regarding the principle of division of labor. (4) To give added practice in applying scientific method.

Chapter V

Figure, p. 70. To be certain that the result obtained was not merely a chance happening.

Experiment 7, p. 70. The leaves from the plant which stood in the light showed that food-making had been going on, while the leaves from the plant kept in the dark did not show any starch. Scientific Method: The conditions that were the same were (1) both plants were kept in the same place, ensuring that the temperature was the same; (2) the plants were similar and were growing in similar pots of soil; (3) the treatment of the leaves after they were removed from the plant was the same. The condition that was different, that is, the experimental factor, was the amount of light. The leaves left in the dark were controls because they showed that the results were due to the experimental factor. It is better to experiment at one time with but one experimental factor because then one can be sure that that factor is responsible for whatever differences in results one obtains.

Figure, p. 71. The leaves are so placed that they do not shade one another; consequently each can secure a desirable amount of sunlight. Also, they have the flat surface exposed to the sun.

Experiment 8, p. 72. Plant stems tend to grow toward light. Check Experiment: After the plants are turned around, the leaves will again turn toward the light. Scientific Method: Two plants were used to make certain that nothing in the shape or the individual qualities of the plant caused them to bend in the direction observed. All the factors except the position of the window were identical.

Figure, p. 72. The check experiment enables one to be certain that the result he obtains is due to the experimental factor (light), and not to any peculiarities in the plants themselves.

Figure, p. 73. Climbing plants depend on trees or other supports to enable them to hold their leaves up to the light.

Figure, p. 74. Similarities: The leaves are arranged so that one does not shade another; the lower leaves are larger, and the smaller, upper ones do not shade them. Differences: in the rosette the leaves are attached to a very short stem; in the second year's growth they are distributed along a tall stem.

Note: Mullein is a biennial. During the first year it is a rosette plant. In the second year the stem elongates, thus exposing the flowers for pollination and the seeds for wider distribution.

Figure, p. 76. The original tree was cut down or was blown down. Then two branches grew upright, probably in response to both gravity (negativ geotropism) and the sunlight, and have now assumed the form of trees. Smaller branches grew in positions to secure the greatest amounts of light.

Figure, p. 77. Similarities: Both spread their branches in the air and expose their leaves to light; both have similar gross structures, such as roots, trunks, branches, and leaves. Differences: The evergreen tree is cone-shaped, the deciduous more branched, thus more spreading; the deciduous tree has lost its leaves, the evergreen tree retains its leaves.

Self-test, p. 77. 1. R. 2. Change greater to shorter. 3. R. 4. R. 5. R. 6. Change deciduous to evergreen.

Self-test on Biological Principles, p. 78. 1. Plants which can grow faster or taller than other plants in the same area have the advantage of getting their leaves up in the air where they can secure adequate sunlight. On any given plant the same struggle for light often occurs. Lower branches may be so shaded that they will die, as we can note on many evergreens. 2. Most green plants have stems, on which the leaves are arranged in various fashions to expose most of their surfaces to light. Lower branches are longer than upper ones; lower leaves are larger or have longer petioles; the leaves themselves are flat and comparatively thin.

Problems, p. 78. 1. The rosette covers the ground closely and thus prevents evaporation of moisture. 2. Broad leaves present a maximum of surface to the light; thin leaves make it easier for the light to penetrate to all the cells.

Chapter VI

Figure, p. 79. The epidermis protects the inner tissues of the leaves against too great loss of water and against injury by some insects or by contact. Veins serve to conduct liquids, to support other leaf parts, and to give shape and rigidity to the leaf.

Figure, p. 80. The upper and lower epidermis protect the other leaf structures. The palisade and spongy tissues are the principal chlorophyll working structures. Veins give support and conduct liquids. The stomata allow air to pass into and out of the leaf.

Experiment 9, p. 81. There are more stomata on the lower epidermis of most leaves. In this position the stomata are less likely to become stopped up by dust or moisture, which is likely to settle on the upper surface. Also, they are usually in less danger from unfavorable weather and intense light.

Experiment 10, p. 81. The chloroplasts of Elodea and moss are round or oval. There are probably ten to twenty. Usually movement of the cytoplasm, which carries the chloroplasts about, can be observed if the leaves have been kept in a warm light place for a time before the experiment is begun.

Figure, p. 82. The ends of the veins appear as darker dots in the leaf scar.

Experiment 11, p. 82. The white parts of the leaf do not show the presence of starch. The green parts produce starch. From these facts one can infer or conclude that chlorophyll is necessary for the production of starch. Check Experiment: No chlorophyll can be removed from leaves that have been kept for a long time in darkness. If the leaves are placed in sunlight for a few hours, even then no starch test will be obtained, indicating that chlorophyll as well as sunlight is needed for photosynthesis. Scientific Method: A check experiment is of value in indicating that only the one factor under experimentation is responsible for the results obtained; further, it shows that the same results can always be expected if the conditions are the same. In Experiment 11 the white spots served as controls, since they were kept under exactly the same conditions as the green parts of the leaves.

Experiment 12, p. 83. The gas collected in the test tube above plant A causes a glowing splint to burn more brightly, indicating that the gas is oxygen. There was no gas above B. Sunlight is the only factor which is different; in other respects the two jars with their plants are exactly alike. Scientific Method: All conditions were the same except that one plant was covered while the other remained in the light. The light was the experimental factor. It was necessary to have only one condition different in order that one might be certain that the difference in results was due to that factor. It was desirable to repeat the experiment with jars A and B reversed, to be sure that there was nothing in the plants themselves or in the other conditions that might have influenced the result. If no gas was found above either plant, it would not conclusively prove that neither gave off a gas. There might have been gas produced which was used by the plant or which was absorbed or dissolved by the water.

Figure, top of page 86. Sugar manufactured in the leaves is transported to the underground stems through the phloem of the fibrovascular bundles. It is then changed to starch by enzymes and is stored.

Figure, bottom of page 86. Carbon dioxide is used by green plants in photosynthesis, and oxygen is given off. This oxygen is used by animals in respiration, and carbon dioxide is given off by them. This figure also shows how a high-school pupil can make good biological illustrations.

Self-test, p. 87. 1. (1) permit air to pass in and out; (2) regulates the size of opening of the stoma; (3) manufactures food; (4) transport water and food materials. 2. Photosynthesis. 3. (a) water; (b) carbon dioxide, water vapor, oxygen. 4. Carbon, hydrogen, oxygen. 5. Change fats to starches; change carbohydrates to fats. 6. Change starch to sugar. 7. R.

Experiment 13, p. 87. The air bubble travels across the horizontal tube, indicating that water is passing over into the jar containing the plant, to replace the water used by the plant. When the plant is stripped of all its leaves, the air bubble moves little or not at all, indicating that only a small amount of water is given off by the stem of the plant.

Figure, p. 88. The plant with the leaves removed is exactly as it was before except for the leaves, which constitute the experimental factor.

Figure, p. 89. 60 x 30 x 5-1/3 x 7.47 = 71,712 gallons.

Figure, p. 91. In early spring before the leaves of trees are out and shade becomes too dense.

Self-test, p. 92. 1. Transpiration. 2. R. 3. Their leaves are smaller and narrower, and they have fewer stomata. 4. Change more to less.

Self-test on Biological Principles, p. 92. Roots take in water; veins transport it to the leaves; chlorophyll in the leaves makes food; stomata admit carbon dioxide; veins transport manufactured food; stems hold leaves up to sunlight.

Problems, p. 92. 1. The summary on page 87 is a good discussion. 2. Plants give off moisture (transpiration) which is condensed and falls as rain, is taken in by roots, and again transpired. 3. Since evergreens always have some leaves, photosynthesis can go on all the year, and food can be made as needed. 4. Too close pruning removes too many leaves, and the plant may not be able to make enough food to keep alive. 5. To protect the inner cells from drying or being killed as the sun shines on the upper surface. 6. To prevent too great transpiration at a time when the roots cannot get large quantities of water. 7. (1) Buds may open and then be killed in succeeding cold weather; (2) sap starts to flow and transpiration begins. The tree may then lose so much moisture that, if the roots cannot obtain more from the frozen soil, the protoplasm may not have enough water to carry on life activities; (3) the protoplasm freezes more readily when it is well supplied with moisture. 8. To a small extent only. Practically no water can enter through the stomata. Sprinkling may help to revive the plant by providing a moist atmosphere next to the leaf and by thus reducing the amount of transpiration. 9. Stomata would probably be found in equal numbers on both sides. Palisade tissues may be found next to both upper and lower epidermis. 10. On the upper surface, since the lower surface is in contact with water.

Exercise on Scientific Method (Making Hypotheses), p. 93. The deciduous trees have a heavy load of broad leaves, and hence present more surface to the wind. Many deciduous trees have wide-spreading branches.

Figure, p. 93. Yes, any plant which contains chlorophyll carries on photosynthesis, no matter what its shape. In the cactus the green stems carry on photosynthesis, though the leaves have been reduced to spines, or prickles.

Chapter VII

Figure, p. 95. The grape-vine is an independent plant, since it contains chlorophyll and carries on photosynthesis. It is dependent on some other object only for support.

Figure, p. 96. Stems, as asparagus and sugar cane; fruits, as apple and grape; leaves, as cabbage and spinach; seeds, as rice and peas; leaf petioles, as rhubarb and celery. Some underground stems, like bulbs, are closely packed, thickened leaves; many underground stems, as tubers (like the white potato) and rhizomes (like those of iris or fern), bear buds. Roots have neither of these characteristics.

Experiment 14, p. 96. The epidermis is brown, gray, or green, depending on the species of plant used; the cortex is green. The pith is softer than the woody region. It was better to use several kinds of stems to be certain that the conclusions made were generally true and were not peculiar to one kind of stem.

Figure, p. 97. Similarities: Both have cortex, pith, and fibrovascular bundles. Differences: The arrangement and distribution of the fibrovascular bundles are very different. Those of the monocot are scattered throughout the pith; those of the dicot are arranged in a ring inside which is the pith.

Experiment 15, p. 97. In the monocots the regions which will be colored with the red ink will be scattered irregularly throughout the stem. In the dicots the colored region will be a definite band about the stem, just within the bark probably. Scientific Method: It is better to use several stems to be sure that the observations made and the conclusions drawn are not peculiar to the one plant used but are generally true of that kind of plant.

Experiment 16, p. 97. The vascular bundles of the monocot are scattered throughout the pith; those of the dicot are arranged in a cylinder around the pith.

Experiment 17, p. 98. The thin section of cornstalk shows large irregular (usually five-sided or six-sided) cells of pith; also more compact groups of cells, which are the vascular bundles. In a vascular bundle one observes (1) three or four large openings, which are the cut ends of the tubular cells of the xylem, and (2) a region of smaller cells, which is the phloem. The cross section of the dicot will look very much like the figure on page 97. The vascular bundles of the dicot are arranged in a rather definite ring, surrounding the pith. The tissues shown in the figure from the exterior to the middle are (1) epidermis (one layer of cells); (2) cortex (small cells, green in a fresh stem); (3) cork cambium, or bark cambium, shown in the figure as a darker band about three or four cells thick (this layer is not obvious in all stems, and probably its importance should not be stressed for young students); (4) phloem, shown as small rectangular cells toward the outside of the vascular bundle; (5) cambium, shown as larger rectangular cells forming a band which connects the vascular bundles (in a section the cambium cells will probably appear smaller than those in the diagram); (6) xylem, or wood region (in this, one observes the large openings of the xylem tubes and the small heavy-walled cells which serve for support); (7) pith, the central region of large cells (the pith extends between the vascular bundles, forming pith rays).

Self-test, p. 99. 1. Change all to some (or perhaps many or most). 2. Outer protective layers of epidermis and cortex; vascular bundles, which include some tissues carrying liquids upward and others that carry them downward; pith region (or sometimes only pith rays) for food storage and horizontal transfer of water. 3. It should read: epidermis, cortex, vascular bundles, pith. 4. Change old to young. 5. Change cambium to xylem. 6. Change xylem to phloem. 7. Change phloem to cambium. 8. Change center to outside. 9. Change cambium to pith. 10. Change vertically to horizontally.

Experiment 18, p. 100. Buds are covered with bud scales, which may be held together by sticky secretions or may be covered with down which aids in shedding water. Within the dormant bud one finds all the leaves, the stem, the flower parts which will appear as the bud develops. In the process of growth of a bud the parts merely increase in size.

Figure, p. 101. The lilac twig is one year old; the horse-chestnut twig shows nine clear growth rings (bud-scale scars).

Figure, p. 102. See pages 98 and 102.

Experiment 19, p. 103. In nearly all cases trees make one growth ring each year. In very rare cases of two growth periods that are separated by a long drought, two small growth rings might be made. This is so rare as to be negligible in making the count. Old bud-scale scars provide another way to determine the age of a twig because the bud which was enclosed by the scales contained all the structures for one year's growth. Therefore every region between two bud-scale scars is one year's growth.

Figure, p. 103. By counting the annual rings.

Self-test, p. 104. 1. See pages 100-101. 2. Change sides to ends. 3. Change cortex to leaves. 4. Change flowers to buds. 5. Change monocotyledons to dicotyledons. 6. Change always to usually or typically. 7. See page 103.

Experiment 20, p. 104. Such plants as dandelion, plantain, carrot, and beet have a taproot, with numerous smaller secondary roots. Corn, clover, and pigweed have several rather large roots of about equal size. Grasses have numerous fine roots (fibrous roots). Some of the taproots are definitely food-storage roots, as in the carrot and the beet. Scientific Method: Since only a few roots have been examined, one would not be justified in concluding that he had seen all the types of roots.

Figure, p. 105. Roots are usually as widespread as the branches or even more widespread than the branches, and many roots extend deep into the ground.

Experiment 21, p. 105. In the seedlings the primary and secondary roots will be easily found, as shown in the figure on page 106. The numerous secondary roots extend in various directions and thus aid in absorbing water. On them one may find root hairs, which serve to increase the absorbing surface.

Experiment 22, p. 105. The vascular-bundle region usually appears as two dark lines extending through the root. In cross section this region forms a ring, as it does in a stem. The root is made up of cells, as can be seen most easily near the root tip. (If the root is too large to show cells readily, cut a longitudinal section or crush the root.) The root hairs are most numerous a short distance back from the tip of the root. The tip of the root is covered with a rootcap made up of several layers of epidermal cells. The outer layers of the rootcap are the dead cells.

Figure, top of page 106. Similarities: both seedlings have roots, stems, and leaves. Differences: the bean has a taproot; the corn has several distinct roots. The bean has two distinct leaves; the corn has a single shoot.

Experiment 23, p. 106. A root hair is an outgrowth of an epidermal cell, as shown in the figures on pages 106 and 107.

Figure, bottom of page 106. See page 106.

Figure, p. 107. Epidermis, protection and absorption; root hair, absorption; cortex, food storage and protection; fibrovascular bundles, transportation of water upward and of food downward.

Figure, p. 108. The island soil is rocky and sandy and does not provide good anchorage. It lacks the humus and mineral constituents which would make it fertile. The necessary anchorage can be provided by wire netting and the necessary elements can be supplied in the water when they are grown in tanks.

Self-test, p. 109. 1. Change pith to root hairs. 2. Root hairs. 3. Fibrovascular bundles. 4. Change more to fewer. 5. Change more to less.

Figure, p. 110. Leaves are attached to a stem; also, the leaves show veins.

Self-test, p. 110. 1. Change human beings to its offspring. 2. R. 3. Change roots to underground stems. 4. Water. 5. R. (None until the roots are large enough to absorb the decaying flesh.) 6. R.

Figure, p. 111. Rain falls infrequently in desert regions; therefore the plant which can store water can carry on its life activities even when water in the soil is scarce.

Self-test on Organization of Materials Illustrating a Principle (Division of Labor), p. 111. Division of labor is the performing of special functions by special organs or parts of the plant. I. Roots. A. 2. To absorb water and mineral salts. B. 2. To store food. 3. To propagate the plant.

II. Stems. A. Unique functions. 1. To support the leaves and flowers. 2. To conduct liquids between roots and leaves. B. Functions shared with other parts. 1. To transport water and food materials. 2. To store food. 3. To propagate the plant. 4. To carry on photosynthesis (when green). 5. To carry on transpiration.

III. Leaves. A. Unique functions. 1. The leaves have no functions which are unique, that is, unshared by other organs, but leaves are the chief organs o photosynthesis and transpiration. B. Functions shared with other parts. 1 To store food. 2. To transport water and food materials.

Self-test on Organization of Facts, p. 112

MONOCOTYLEDONS: Similarities of Stems: 3. Have cortex. 4. Have pith.

Differences of Stems: 2. Vascular bundles scattered. 3. Vascular bundles lack cambium, except when young. 4. Rind-like cortex. 5. Pith throughout the stem.

Similarities of Leaves: 1. Have food-making tissues. 2. Have veins for transportation. 3. Have stomata for exchange of gases.

Similarities of Roots: 1. Anchor the plant. 2. Absorb soil water and minerals.

Differences of Roots: 1. Usually annual (since there is no cambium to continue growth). 2. Usually have fibrous roots.

DICOTYLEDONS: Similarities of Stems: 2. Have cortex. 3. Have pith.

Differences of Stems: 2. Vascular bundles in a ring. 3. Vascular bundles have continuously growing cambium. 4. Cork-like cortex. 5. Pith on the middle of the stem.

Similarities of Leaves: 1. Have food-making tissues. 2. Have veins for transportation. 3. Have stomata for exchange of gases.

Similarities of Roots: 1. Anchor the plant. 2. Absorb soil water and minerals.

Differences of Roots: 1. May be annual, biennial, or perennial. 2. Usually have taproots.

Problems, p. 112. 1. Such a cut in a dicot would sever all the phloem tubes, preventing storage of food in the parts of the plant below the cut. In a monocot the fibrovascular bundles are scattered, and not all will be cut. 2. Bark protects against gnawing animals and insects, cold, loss of water, and fire. 3. Uses of stems: lumber, paper, cloth, rope, sugar, rubber, etc. 4. The surplus food would be lost when the leaves were shed. 5. Because the protoplasm in the cortex has died, leaving only a hard substance or rind. A hollow cylinder is always stronger than a solid cylinder of the same volume. 6. Warm days may result in growth of root hairs, passage of sap up to leaves, and transpiration of considerable water. If cold weather follows and prevents securing of more water, the tree may not have enough for the protoplasm to carry on activities and remain alive. 7. Since water is in contact with the plant, devices for absorption of water are not necessary. 8. The sugar which has been manufactured in the leaves has not yet been converted to starch or protein for storage. 9. It will still be three feet from the ground. The tree grows in height at the tips of branches.

Exercise on Scientific Method, p. 113. 1. A rhizome, or rootstock, is the type of underground stem which most resembles a root. It is usually elongated and not of great diameter. A tuber is shorter and thicker than a rhizome. A bulb has a very small stem, to which are attached greatly thickened leaves folded around one another. A corm is a rounded underground stem, resembling a bulb in general outline but lacking the thickened leaves of the bulb. 2. By late summer most of the food-making activity of the year is completed, and the food is stored in the stem or roots. Consequently even if it is girdled then, it will have plenty of food to put forth leaves the following spring. Since, when a tree is girdled, the xylem tubes are not commonly cut, water can be transported up to the leaves during all the following summer. But the food manufactured cannot be transported below the cut which destroyed the phloem tubes. Consequently the tree will have no stored food to start its work or maintain its life the next year.

Figure, p. 114. It provides spaces for roots of various sizes. Small-mesh wire would restrict large roots.

Figure, p. 115. The larger trees are enemies of lower-growing plants because they prevent them from getting ample sunlight. There are probably insect enemies present. Man is an enemy in so far as he prevents plants from using the soil in the road. The struggle for light is evidenced in the fact that the trees have few or no branches except at the top; the lower branches have been shaded and have died. One tree shows a number of dead branches. Other topics suggested: trees of different habits of growth, evergreen and deciduous; several small trees, tall but of small diameter, growing in the shade of the larger trees. Principles suggested: (1) Living things affect one another in various ways. (2) All living things carry on a struggle for survival. (3) Sunlight is an important factor in the growth of green plants.

UNIT III

Unit Objectives: (1) To present acquaintance with the leading kinds of plants and animals. (2) To give an understanding of the fact that the enormous numbers of living things can be scientifically classified on the basis of their structure. (3) To enable pupils to learn that both animals and plants vary from one-celled individuals to extremely complex organisms and that the progression from simple to complex is in fairly definite stages. (4) To develop an increasingly clear comprehension of the close relations between structure and function. (5) To provide knowledge of the characteristics of the great phyla, so that this knowledge may serve as a basis for better comprehension of biological principles developed in later units. (6) To show how different groups and kinds of living things are equipped to compete for survival.

Chapter VIII

Figure, p. 119. By observation of form and structure, of special structures of the organs for carrying on life processes, and of habits of the animals.

Figure, p. 120. Cat, tiger, leopard, and any other cat-like animals.

Figure, p. 121. Deer; tiger or leopard, or other cat-like animal.

Figure, p. 123. Classification of the fox would differ after family; of fish, after phylum. Fir tree and lily belong to the same phylum as dandelion, since all three are seed plants.

Figure, p. 125. The butterfly and the moth would differ in genus and species.

Self-test, p. 125. 1. Change habits to structures. 2. Change three Greek to two Latin. 3. Species, genus, family, order, class, phylum. 4. Change phylum to genus; change order to species.

Exercise on Scientific Attitudes, p. 126. Attitudes 1, 6, 7, 8, 9, especially.

Scientific Method (Using Controls and Check Experiment), p. 126. He would use several specimens to ensure that slight variations characteristic of only one individual were not used in his description.

Chapter IX

Figure, p. 127. The plants grow so closely that it is probably difficult for all to secure light; also, all must struggle to secure sufficient carbon dioxide and other materials for their food.

Figure, p. 129. Pleurococcus is successful in its struggle for energy because it is able to get its food materials in a wide variety of situations.

Figure, p. 130. There is a crescent-shaped diatom, slightly left of the center, resting on the zigzag filament of algae.

Experiment 24, p. 130. In most kinds of algae the cells will be somewhat similar. Chloroplasts may be rounded or oval, irregularly star-shaped, or in bands. (It is not important that pupils try to identify the algae, but they should see and appreciate the structure of these simple plants.)

Experiment 25, p. 131. (Teaching aid for microscopic examination of bacteria.

The rod-shaped bacteria found in sauer-kraut juice are large and easily seen, but one can obtain relatively large forms from many sources. The scum that forms on water in which grass or leaves is decaying sometimes furnishes good material.) The culture dishes are all kept in the same place so that conditions may be the same. The first colonies may appear as early as the next day, or at least by the second day. While the individual bacteria cannot be seen, the masses of bacteria may be seen as colonies. One is likely to find colonies of many colors -- pure white, cream, yellow, pink, red, etc. Colonies differ in shape and surface appearance. Scientific Method: The unopened dish serves as a control in showing that the culture medium contained no bacteria until it was exposed.

Figure, p. 132. Molds, yeasts, mildews.

Experiment 26, p. 133. Suggestions: If a drop of iodine is added to the solution on the slide, the starch grains which helped to form the yeast cake will be stained blue, and the pupil will not confuse them with the yeast.

Figure, p. 134. Molds and yeasts grow on food which man uses. Mold, for example, may grow on bread or fruit; and yeasts (as well as bacteria) may cause canned fruit to ferment.

Experiment 27, p. 134. The parts which appear under a hand lens may be better shown by use of demonstrations under a compound microscope.

Figure, p. 136. Food material is absorbed and stored in the mycelium. Buds which develop can increase in size very rapidly by use of this stored food, whenever the temperature and moisture conditions become favorable. Thus the mushroom may come up during one night.

Self-test, p. 136. 1. See pages 128-129. 2. Change some to no. 3. 3. Change dependent to independent. 4. Change fungi to algae. 5. Change yeasts to bacteria. 6. Change all to some. 7. (2). 8. Heat, moisture, food, darkness. 9. Change all to some. 10. Change all to no.

Figure, p. 137. The fungus could not survive without the food produced by the alga. The alga would dry out and could not secure water for food-making if it were not protected by the fungus.

Experiment 28, p. 138. The moss plant has leaves, a simple stem, and root-like structures called rhizoids. The spore cases are found usually for only brief periods in the life of the whole moss plant.

Figure, p. 139. Neither one is a parasite or a saprophyte. Both contain chlorophyll and carry on photosynthesis to make their own food.

Self-test, p. 139. 1. Change some to none; change some to none. 2. Osmosis. 3. R. 4. Change liverworts to mosses. 5. Stems, leaves, rhozoids.

Figure, p. 140. Any of the ferns.

Figure, p. 141. Because in the tropics, where the temperature and humidity are higher, the growing season is practically continuous.

Self-test, p. 141. 1. Change seeds to spores. 2. Change roots to stems. 3. Change small to large. 4. R. 5. Change like to unlike. 6. R. 7. Fibrovascular.

Figure, p. 142. The evergreens are gymnosperms; the various flowering plants are angiosperms.

Figure, p. 143. Similarities: Both possess the parts of a new plant. Differences: Corn has one cotyledon; bean, two. Food is stored in corn as the endosperm layer; in the bean it is stored in the cotyledons. The plumule has two leaves folded together in the bean; in the corn it is a tightly rolled shoot.

Experiment 29, p. 143. Suggestions: If it seems desirable at this point, seeds may be planted to show what structures of the plant develop from various parts of the seed. The meaning of seed leaf will be clear to pupils when they have seen the cotyledons (seed leaves) of the bean come above ground and develop chlorophyll. (In some dicots, as the pea, the cotyledons remain below ground.)

Figure, p. 144. Solomon's seal and calla lily are monocots; the rest are dicots.

Experiment 30, p. 144. Technically the corn grain is more than a seed because it has extra coats outside the testa, or seed coat. The hypocotyl points toward the end of former attachment of the corn grain. It is protected by the hypocotyl cap.

Experiment 31, p. 146. In each small flower of the dandelion cluster, for example, the five petals are united into a strap-shaped corolla. The stigma is distinctly two-parted. The stamens are united into a tube around the pistil, slightly below the stigma. The whole dandelion cluster, or head, is composed of similar flowers. But in many composites, such as the sunflower, there are ray flowers with strap-shaped corollas and disk flowers with tubular corollas.

Self-test, p. 146. 1. Change some to all. 2. Change monocot to dicot.
3. Change usually to seldom. 4. Change dicots to monocots. 5. R.
6. Compositae.

Self-test on Biological Principles, p. 147. Simple plants, as bacteria and yeasts, carry on all life processes in the single cell. Molds have rhizoids, which anchor the plant and absorb food materials. Mosses have rhizoids; leaves, which perform photosynthesis; stems, which hold the leaves to the light. Ferns have, in addition to roots, stems, and leaves, a vascular system. Higher plants have flowers, which produce seeds.

Problems, p. 147. 1. Water in deep wells has filtered through layers of soil, which usually removes all solid matter. Surface water can pick up bacteria from animal wastes and from the surface soil. 2. By heating cooked foods to kill all molds and by then covering them to prevent entrance of spores; by drying foods, and by keeping such articles as leather in a dry place; by using preservatives. Paraffin prevents entrance of mold spores from the air.
3. Bracket fungi are found on trees or stumps. Some are parasites and may kill the tree. 4. Thallophytes: bacteria, mushroom, yeasts, molds, rusts, and smuts, which may cause disease, or may destroy man's food. Bryophytes: sphagnum moss, from which peat is formed. Pteridophytes: Lycopodium (see page 141), from which a useful powder is made. Spermatophytes: the lumber trees, the grains, etc., from which timber and foods are secured.

Chapter X

Experiment 32, p. 149. *Scientific Method*: The Protozoa were probably on the pond weeds or the grass. If the material was dry, the Protozoa were encysted and resumed life activities when conditions were right.

Figure, p. 150. All are one-celled animals.

Figure, p. 151. Division of labor is found in *Volvox*. A *Volvox* colony may be discerned at the right of the middle of the figure on page 127.

Figure, p. 153. In the warmer oceans.

Self-test, p. 154. *1*. Change *few* to *no*. *2*. Change *dependent on* to *independent of*. (In a few cases, as *Volvox*, the individual protozoa are slightly dependent.) *3*. *Volvox*. *4*. Change *saprophytes* to *parasites*. *5*. Transpose *fish* and *Protozoa*. *6*. Millions. *7*. Change *few* to *all*. (When dry, they are dormant or they may die.)

Figure, p. 155. Any animal is successful if it can secure energy for itself and can produce offspring. The sponges show no signs of decreasing numbers.

Figure, p. 156. The larva has a very different appearance from the adult.

Figure, p. 157. The Secretary of the Chamber of Commerce at Tarpon Springs has interesting material on the sponge industry. Also, the encyclopedias present interesting discussions of this topic.

Self-test, p. 157. *1*. (4). *2*. Change *Protozoa* to *Porifera* or *sponges*. *3*. Change *three* to *two*. *4*. *R*. *5*. Change *few* to *none*. *6*. (2). *7*. Skeleton.

Figure, p. 158. All have two-layered bodies, with a central cavity; all have tentacles and stinging cells; all are radially symmetrical; all have one body opening.

Figure, p. 159. No, it is not a parasite. It captures its food.

Figure, p. 161. The jellyfish shows alternation of generations in that the hydroid gives rise to medusae, and the medusae give rise to hydroids.

Figure, p. 162. Sea anemone, sea dahlia, sea fan, jellyfish, Hydra, and hydroids are a few.

Figure, p. 163. Warm, since corals are found only in warm water.

Self-test, p. 163. *1*. Change *all* to *some*. *2*. (5). *3*. *R*. *4*. Change *great* to *slight*. *5*. Change *hydras* to *corals*.

Figure, p. 164. Forty-six hundred species of flatworms. The exact number is not important to remember.

Figure, p. 166. Cook thoroughly all meat that is eaten.

Figure, p. 167. See pages 166-167.

Self-test, p. 167. *1*. Change *two* to *three*. *2*. Platyhelminthes, Nemathelminthes, Annelida. *3*. Change *saprophytes* to *parasites*. *4*. Change *photosynthesis* to *osmosis*. *5*. *R*. *6*. *R*.

Figure, p. 169. The study of biology reveals the life history of the hookworm parasite, also what it eats, how it enters the body, and how one may avoid having the hookworm disease.

Figure, p. 170. Cook thoroughly all pork used as food.

Self-test, p. 171. 1. (3). 2. R, in regions in which this disease exists. 3. Change few to many. 4. Change small to great or considerable. 5. Trichinosis.

Figure, p. 172. Littoral means "shore." They are not found in deep water, but inhabit the shallow water of the ocean shore.

Figure, p. 173. See page 172 for explanation of tube feet.

Self-test, p. 173. 1. Change few to all. 2. Change great to small. 3. Change starfish to sea cucumber. 4. (1), (3), (6), (7).

Figure, p. 174. Earthworm or leech.

Experiment 33, p. 174. The head end is distinguished by the light-colored band, or clitellum. The worm usually crawls headfirst. The worm may be nearly twice as long when stretched out as it is at rest. The number of segments varies in different species of worms and in different individuals. There are four setae on each segment. They are useful in keeping the worm from slipping backward as it crawls.

Figure, p. 175. There are five pairs of hearts, a ganglion in each segment, and excretory tubes in each segment. Where structures are not specialized for many kinds of work, the organism cannot carry on as complex life activities and is therefore simpler, or more primitive. In general, the more primitive the organism, the greater the number of its duplicate parts.

Experiment 34, p. 175. Each segment is separated from the next by a fine partition. The digestive tract extends straight through the body; the intestine is not coiled. The blood flows toward the head in the dorsal blood vessel.

Self-test, p. 176. 1. Change external to no. 2. Segments. 3. Earthworm. 4. (1), (4), (5). 5. R.

Figure, p. 177. Fresh-water mussel, oyster, clam, and to a somewhat lesser extent scallop, snail, and squid.

Figure, p. 178. Oldest part of shell at upper left. The long siphon enables the clam to lie buried deep in the sand, out of sight of enemies.

Figure, p. 179. Is sometimes called a partial parasite. It may absorb some food from the tissues of the host, and it is dependent for protection; but it does not injure the host unless the tiny mussels are present in too great numbers. It does, however, depend on its host to be moved about in the water.

Self-test, p. 180. 1. Change all to most. 2. Change bones to shell or exoskeleton. 3. Change all to most. 4. R (because the larva does not resemble the adult mussel). 5. Clam, oyster, snail, squid, scallop, abalone. 6. (1), (3), (4), (5), (10), (11).

Self-test on Biological Principles, p. 181. 1. Symbiosis, which may be stated thus: Certain organisms of different kinds are able to survive or to survive more easily by forming partnerships. 2. The balance of nature was destroyed because there were too many enemies of the lobsters and crabs.

3. The more mature the offspring is at birth and the greater the amount of parental care, the less is the need for numerous offspring in order that the species may survive.

Problems, p. 182. 1. Exterminate snails which act as hosts. Or better, arrange drinking water for sheep so that manure cannot pollute it or snails live in it. Now that biologists understand the life cycle of the liver fluke, they have knowledge which should enable all sheep-raisers to protect their flocks against this parasite. It might be dangerous to drink water running through a sheep pasture because it might contain liver-fluke larvae, which would attack one's liver. 2. No, well-cooked pork is safe to eat; even if trichinosis parasites were present, they would be killed. Also, the Italian family ate the infected meat several weeks before the disease developed.
3. A temporary parasite causes occasional injury; an animal of prey may cause immediate death. 4. Octopus, clam, snail: Mollusca; sponge: Porifera; Amoeba, Vorticella: Protozoa; coral: Coelenterata; tapeworm: Platyhelminthes; hookworm: Nemathelminthes; sandworm: Annelida. 5. Protozoa, as malarial parasite. Platyhelminthes, as tapeworm. Nemathelminthes, as hookworm.

Exercises on Scientific Method, p. 182. 1. To discover whether earthworms are "rained down," place a tub or other container where rain can fall into it, but where worms cannot crawl into it. Worms come to the surface after a heavy rain because their burrows become filled with water. They soon use the oxygen dissolved in this water and must come to the surface, seeking free air.
2. The tapeworm has no skeleton, but is supported by the liquid contents of the intestine of its host. It has no exoskeleton and needs none because it is protected by the body of its host. 3. The octopus places the disk-covered surface of its arms or tentacles against its prey. Contraction of muscles then increases the depth of the cuplike disks. There is therefore a decrease in the air pressure within the cup. The normal water pressure outside is therefore greater and holds the arms tightly against the prey.

Chapter XI

Figure, p. 186. Advantages: protection against attack, against being crushed or wounded. Disadvantages: the difficulty of movement and the weight of the armor, with consequent possible sacrifice of speed.

Figure, top of page 187. Peripatus is found in some parts of Australia, New Zealand, Africa, South America, Mexico, and elsewhere. Although it exists in many parts of the world, it is found only in widely separated sections. It is a worm-like animal, with fleshy legs on each segment. It lives in dark crevices and feeds on insects and other small animals. It breathes through tracheae.

Figure, bottom of page 187. They are food for the small fish which may grow large enough for man to use them for food.

Self-test, p. 188. 1. Segments. 2. Change abdomen to body. 3. Change few phyla to no phylum. 4. Insecta: bee, grasshopper; Crustacea: crayfish, lobster; Arachnida: spider, scorpion; Myriapoda: centipede, millepede.
5. Change some to no. 6. Change most to few.

Figure, p. 189. Considerable quantities of water can be retained under the carapace. As long as the gills are moist, oxygen can dissolve in the film of water.

Experiment 35, p. 189. 1. The large legs are used but little, probably because they are heavy and hard to move. It determines where it is going by continually moving its antennae around and by thrusting the eyes outward on their stalks. In escaping from danger the tail fin is spread out, thus affording greater surface which pushes against the water. (See also pages 192-193.) 2. Similarities: Crayfish and insects are alike in possessing jointed exoskeletons; they have antennae, jointed legs, and compound eyes. Differences: Crayfish differ from insects in that the head and thorax of the crayfish are united; in that it has appendages attached to the abdomen; in that it has two pairs of antennae, no wings, and five pairs of legs instead of three. The crayfish has two body regions, known as the cephalothorax and the abdomen; the insect has three, the head, the thorax, and the abdomen. The insect's head is movable, while that of the crayfish is firmly attached to the thorax. The crayfish has many more appendages than the insect. Instead of having six legs, like an insect, the crayfish has four pairs of walking legs and one pair of claws for securing and holding food and for fighting. All the legs of the insect may be very similar, as in a fly; or the third pair may be enlarged as jumping legs. The crayfish has one pair of large claws for securing food and for fighting; the first two pairs of walking legs have pincers that may aid in holding food; the last two pairs of legs are used only for walking. The crayfish has two compound eyes but, unlike such insects as the grasshopper, has no single eyes. The compound eyes are like the eyes of an insect in general structure but are on jointed and extensible stalks instead of being set into the head. The antennae of the crayfish and of the insect are similar in being segmented and readily movable. The mouth is on the under-side of the head, just in front of the point where the large claws join the body. The small leg-like mouth parts (maxillipeds) move about and hold food while the jaws (mandibles) chew or bite off small pieces. The mouth parts move from side to side. 3. The crayfish tries to escape by flipping its tail, pushing against your fingers with its legs, or trying to pinch you. The living animal is usually gray-green or brown. This coloring enables it to rest undetected on the stream bottom. The advantages of the exoskeleton are that it offers a maximum of protection; disadvantages are that it is heavy to carry around and does not permit great freedom of movement. Adaptations for protection are exoskeleton; protective coloring; pincers; sense organs, such as eyes and antennae; ability to move rapidly. The legs have seven joints. These joints make it possible to move in spite of the armor. Muscles are attached directly to the exoskeleton at many points. 4. The ink passes with the water beneath the carapace and, having flowed forward, reappears near the mouth. The gill bailer (a part of the second maxilla) aids in this forward flow by continually moving, thus forcing out water. Gills will be found to be attached to all the legs except the last. (Other gills are attached to the body wall and to the maxillipeds.) Adaptations of the gill for taking in oxygen are (1) the enormous number of filaments, which increase the absorbing surface, and (2) the thin walls, which permit osmosis to go on readily. 5. When viewed from above, the head shows eyes, antennae, and antennules. The head is somewhat triangular in shape. The eyes move readily, for they are on jointed stalks. The outer part of the eye is truly a part of the exoskeleton and is not readily injured. The jointed eye-stalks enable the animal to see behind itself, and to retract the eyes beneath the projecting skeleton when in danger. There are seven segments in the abdomen. All except the last (which is part of the tail fin) bear appendages. 6. The stomach is almost directly above the mouth. In it are three sets of teeth, separating the anterior and the posterior portions of the stomach. Since the animal does not chew its food thoroughly, these teeth aid in reducing the food to fine particles that are more easily digested.

Figure, p. 190. The finely divided gills present a larger surface for the exchange of oxygen and carbon dioxide than would a single tissue.

Figure, p. 181. This can be accomplished by careful comparison of a specimen with the parts of this drawing.

Figure, p. 192. Pupils may cite any organs which perform functions not shared by other parts of the animal.

Self-test, p. 193. 1. Protective coloration. 2. R. 3. Change sting to pincers or claws. 4. Abdomen. 5. R.

Figure, p. 194. Enables it to escape enemies.

Experiment 36, p. 194. 1. The head, thorax, and abdomen are definitely separated from one another. The abdomen is most clearly segmented, or jointed. The head is movable. 2. There are six legs, one pair attached to each section. There are two pairs of wings, one pair attached to each of the last two sections. The inner wings are much larger than the outer wings and are folded like a fan. 3. There are two spiracles (one on each side) on each of the first eight segments of the abdomen. 4. The compound eyes are very large. There are three simple eyes one in front of each antenna and one somewhat lower in the center of the face. The antennae are waved about to touch various objects in the environment. There are several mouth parts. The jaws move from side to side. Characteristics of insects are (1) jointed exoskeleton; (2) six legs; (3) wings usually present; (4) air tubes for breathing; (5) three body regions; (6) compound eyes and, usually, simple eyes.

Figure, p. 195. The sign ♂ indicates male; ♀ indicates female. The grasshopper on the left on page 194 is a male.

Colored plate opposite page 196. Complete metamorphosis is shown by possession of all the stages from egg to adult.

Figure, p. 197. Sponge.

Figure, p. 198. All the stages show marked similarity.

Figure, p. 199. Escape from enemies.

Figure, p. 201. This building has seven stories, above which the towers extend. Numbers of flies are kept down by lack of food, presence of enemies, and unfavorable weather conditions.

Self-test, p. 202. 1. (4). 2. Advantages of exoskeleton: (1) firm enough for protection, (2) light in weight, (3) tough and elastic, (4) affords large surface for muscle attachment. Disadvantage: It does not grow, and must be molted in order that the insect may grow. 3. Three. 4. All except the grasshopper and the cricket. 5. See pages 199-202.

Self-test on Biological Principles, p. 202. See middle paragraph, p. 186; p. 188; p. 192; p. 199; etc.

Self-test on Organization of Facts, p. 202. This comparison is given in the discussion of Experiment 35, p. 34 of this Teachers' Manual. Other points may be added.

Problems, p. 202. 1. Most pupils will say insects because of the damage they cause, but the question is open for discussion. 2. To escape enemies, to secure food, to find places to lay eggs. 3. The powdered borax may clog up the spiracles and thus suffocate the insect. 4. Moisture evaporating from the wet seaweed will keep water vapor in the air about the lobster. Therefore but little water will evaporate from the gills. As long as the gills are moist, air can dissolve in the film of water on them and thus supply oxygen.
5. Jumping, walking, making sounds, carrying pollen, cutting and shaping wax; insects like the praying mantis use the front legs as weapons in capturing their prey; some butterflies have taste organs on their feet (see figure, p. 453).

Exercise on Scientific Method (Planning New Observations), p. 203. Such questions as How large objects can it carry? Are you able to observe any specimens carrying anything which a snake might eat? Does it fly toward you or away from you as you approach? What sort of mouth parts has it? Does it really have a sting or needle-like abdomen?

Chapter XII

Figure, p. 205. Amoeba: Protozoa; Sponge: Porifera; Jellyfish: Coelenterata; Liver fluke: Platyhelminthes; Trichinella: Nemathelminthes; Starfish: Echinodermata; Earthworm: Annelida; Snail: Mollusca; Crab: Arthropoda.

Figure, top of page 206. Great changes in the environment, as of climate, to which it could not become adapted; climatic changes which resulted in lack of proper or sufficient food; increase in number of old enemies; new enemies; inability to escape from enemies readily because of great size; inability to move great distances in search of favorable food or living places.

Figure, bottom of page 206. Amphioxus is a fish-like creature about three inches long, living in shallow ocean waters. It buries itself in the sand, with only the head protruding. It breathes by means of gills. Other facts are given in the text.

Self-test, p. 207. 1. Spinal cord. 2. R. 3. Fish, amphibians, reptiles, birds, mammals. 4. Transpose vertebrates and chordates. 5. Transpose vertebrates and invertebrates. 6. Change hundreds to millions.

Figure, p. 208. Similarities: They both have stream-lined bodies, breathe by gills, use tail fin for swimming, have similarly placed fins. Differences: Perch is covered with scales; armored fish, with bony plates. The head of the armored fish is covered with large plates. Its pectoral and pelvic fins are more leg-like than those of the perch.

Experiment 37, p. 208. The fish has two pairs of fins and three or four unpaired fins. The tail and the caudal fin are used to produce most of the forward movement. The pectoral and pelvic fins are used in stopping, balancing, and turning. When the fish remains in one spot for a time, it usually balances by moving the paired fins and the dorsal fin. The chief purpose of the dorsal fin or fins is balancing and steering. Most fish have scales. Each of these overlaps the one behind it. The eyes are movable. There are no lids. With the eyes placed on the sides of the head the fish can see fairly well both ahead and behind. There are usually four gills on each side, though some species have five. The gill filaments point backward, thus floating in the water that passes from the mouth and under the operculum.

Figure, p. 209. The lateral line is thought to be a special sense organ, though its exact function is not known.

Figure, p. 210. Stomach and intestine.

Self-test, p. 210. 1. R. 2. Change all to most or higher. 3. R. 4. R. 5. Food. 6. Change few to many.

Figure, p. 212. The best inference is that the mud puppy, which is in the water, probably has gills, though there are water animals which breathe by lungs. (The mud puppy does have gills throughout its life; the salamander has lungs in the adult stage.) The broad tail is useful for swimming. Its shape, together with the fact that the animal lives in water, makes this a reasonable inference.

Figure, p. 213. The jelly-like capsule enclosing the egg swells when in water.

Figure, p. 214. The frog has complete metamorphosis, as is shown by the fact that the tadpoles are very different from the adult. A, newly laid eggs; B, the embryos developing in the eggs; C to H inclusive, successive stages during which the tadpole breathes with gills; I and J, air-breathing tadpoles; K and L the young frog after it has left the water habitat.

Experiment 38, p. 214. 1. The frog floats with only the eyes and the tip of the nose out of water. Thus it can see any approaching danger and can breathe without exposing its entire body. When danger approaches, it draws its hind legs up and then quickly kicks backward, forcing the body under water. When you bring your hand quickly toward it (or touch it near the eye), the nictitating membrane is drawn over the eye. This membrane protects the eyeball under water. Other animals which are able to swim entirely submerged except for their eyes are alligators, crocodiles, and hippopotamuses. 2. The frog may remain under water five minutes or even longer, breathing meanwhile through its skin. (The oxygen dissolved in the water passes through the skin, probably by osmosis.) 3. Five toes on each hind foot, four on each front foot. Only the hind toes are webbed. Only the hind legs are used for swimming. Out of water it walks on all four feet. Otherwise it uses the front legs only for support when resting or preparing to jump. In jumping, the hind legs are first drawn up close to the body, then straightened out suddenly. The ankle and foot are almost half the total length of the leg, giving considerable leverage for jumping and swimming. 4. Any of the larger leg muscles will show that one end of the muscle is fastened to the bone, while at the other end a tendon passes across the joint and fastens to the next bone.

Figure, p. 215. Out of water: snakes, turtles, crows, herons, and man. Under water: fish, turtles, snakes, and such insects as the giant water bug.

Experiment 39, p. 216. The heart consists of two thin-walled auricles and one muscular ventricle. It is farther anterior (forward) than that of man. The lungs are sac-like and thin and when inflated extend almost the length of the body cavity. If a lung is examined with a hand lens, capillaries can be seen. The liver consists of three lobes and occupies most of the space between the stomach and the ventral (lower) body wall. The gall bladder lies under the right lobe of the liver. The fat bodies are large in the fall, when hibernation begins, but diminish in size as the stored food is used. They furnish food material during the breeding season too. The nerves which come from between the vertebrae pass through the body cavity because the spinal column ends. (The hump in the back of a frog marks the end of the spinal column. The other supporting bones between that point and the legs are the pelvic girdle.) The nerves control the large leg muscles. The blood vessels in the membrane covering the brain supply needed materials to that organ; there are no blood vessels in the brain itself.

Figure, p. 217. Stomach, intestine, liver, gall bladder, heart, brain and spinal cord, kidney.

Self-test, p. 217. 1. Change some to all; change incomplete to complete.
2. R. 3. R. 4. Change drops off, to become shorter or is absorbed.
5. R. 6. (2). 7. Change salamander to toad.

Figure, p. 218. Perhaps they were infertile; perhaps they were suddenly covered with mud and had no chance to hatch. (Gradually mineral matter replaced the organic matter in the eggs and formed fossils.)

Figure, p. 219. Yes, one would know that the snake must belong to the phylum Chordata because of its bony skeleton and vertebral column.

Figure, p. 221. Protective coloration enables the snake to remain unobserved until its prey is within striking distance. This adaptation is, of course, a disadvantage to those animals that would avoid the snake if it were easily seen. A snake's body lies flat on the ground and undulates from side to side.

Figure, p. 223. Near water. Most turtles are found in or near water.

Figure, p. 224. The Gila monster eats animal food and is especially fond of birds' eggs.

Self-test, p. 224. 1. Change larger to smaller. 2. R. 3. Lungs.
4. Skin. 5. Change all to most. 6. R. 7. R. 8. Rattlesnake, coral snake, copperhead, cotton-mouthed water moccasin, Gila monster.

Experiment 40, p. 225. The body is somewhat boat-shaped. The feathers are of three kinds: quill feathers, which give strength to the wings; contour feathers, which cover the body smoothly; and down feathers, which help to retain heat. The wings are not usually merely flapped up and down, but moved in a figure-8 path. The tail is used largely for balancing and for stopping. The feet typically have four toes, the arrangement of which will differ with the bird studied. The beak varies greatly in different birds (see page 312 for pictures of beaks). The eyes are comparatively large. The parts are essentially the same as in the eyes of many other animals except that there is the third eyelid, or nictitating membrane. This is fastened to the lower inside corner of the eye and is drawn up diagonally. The nostril openings on the beak can usually be seen, though sometimes obscured by feathers. The ears are behind the eyes and are usually well hidden by feathers.

Figure, p. 226. The hoatzin has a claw on the wing, which enables it to climb. Its jaws possess teeth.

Figure, p. 227. The internal organs of frog and bird are very similar. Some organs which the bird has, not possessed by the frog, are crop, gizzard, breast bone, syrinx.

Figure, p. 228. Each type of foot helps the bird to live in the kind of environment in which that particular kind of bird is found.

Figure, p. 229. Protective coloration; this principle might be expressed thus: Certain animals escape detection by their enemies because their body colors blend with those of their habitat.

Figure, p. 230. It is generally believed that the cat does more damage in killing song birds than it does good in killing pests. In the city no cat "pays its way," because it kills so many insect-eating birds; in the country it may be valuable, some authorities maintain, because of the rodents it kills. These authorities state that the cat will catch few birds if rodents are plentiful.

Figure, p. 231. In addition to studying printed descriptions it is useful to take a class to an animal collection in the zoological gardens, if such a collection is available.

Self-test, p. 231. 1. Reptiles. 2. Feathers. 3. Arm. 4. See figure on page 228. 5. Heat. 6. Snakes, squirrels, weasels, hawks, owls, man, cat, insect parasites.

Figure, p. 233. Four limbs, more or less hair, mammary glands, similar internal organs, etc. See page 232 for other examples. (Orders not named on page 232 are Dermoptera, flying lemurs; Pholidota, scaly anteaters; Sirenia, sea cows and manatees; Hyracoidea, conies.)

Figure, p. 234. They are alike because all are the fore limbs of vertebrates, which are built on the same general plan. That is, they are homologous. The limbs differ because each is adapted for a specific use.

Figure, p. 235. The wings are homologous to man's arms; the hind limbs to man's legs; the backbone, ribs, and skull to similar structures of man.

Figure, p. 236. The skull consists of several bones fitted together by immovable joints called sutures. The hip joint and the shoulder joint are ball-and-socket joints, which can rotate in several directions. The knee or elbow is a hinge joint, which bends in one direction only. The ankle or wrist is a sliding joint.

Figure, p. 237. The thin membrane which covers the bone is the periosteum. Bones are bound together at the joints by bands of tissue called ligaments. The ends of the bones are smooth, are usually covered with cartilage, and are lubricated by a fluid (synovial fluid) which lessens friction. The hard bone gives support; spongy bone contains blood vessels (red blood cells are formed here, too). Marrow is found only in long bones.

Self-test, p. 237. 1. Change great to small. 2. Mammals are more or less covered with hair; have milk glands; their young are born alive (except in the lowest order); breathe with lungs; are warm-blooded; and have no true metamorphosis. 3. Change no to few. 4. R. 5. Four; six. 6. Change entirely to largely, partly, or mostly. 7. (6) bones; the others are adaptations for protection. (9) speed; the others are physical characteristics, not activities. 8. Hibernate; migrate. 9. Change carnivorous to hoofed or herbivorous.

Self-test on Biological Principles, p. 238. 1. Even though fish are very prolific, they maintain approximately the same numbers because enemies of various kinds destroy many of the eggs and young. 2. (1) Higher animals such as fish and frogs have digestive systems, circulatory systems, and various other organs, while simple animals such as the sponge do not possess such systems. (2) Fur-bearing animals living in cold climates possess heavier coats of fur in the winter than in the summer. Many species of birds migrate. The dinosaurs and mammoths were unable to migrate to a suitable environment and were unable to become adapted to a changing environment and hence became extinct. 3. The crayfish has ten pairs of legs; an insect has six; a mammal has four, of which the anterior pair is often modified. The earthworm has five pairs of hearts; the frog has a single heart.

Self-test on Organization of Facts, p. 238. (1) Diatoms: a group of algae with siliceous coverings -- phylum Thallophyta. (2) Protozoa: one group (Foraminifera) has a shell either secreted by the body or made of small pebbles cemented together -- phylum Protozoa. (3) Corals: skeleton secreted around the animal -- phylum Coelenterata. (4) Sponges: a network of sponging or of silicon throughout the body -- phylum Porifera. (5) Snail or oyster: heavy exoskeleton of lime, into which the body can be withdrawn -- phylum Mollusca. (6) Ferns: woody cells in the fibrovascular bundles -- phylum Pteridophyta. (7) Flowering plants: woody parts of the fibrovascular bundles form support for dicots, and the bark of a dicot also to some extent serves as support. The outer stem areas of monocots are their chief supporting structure, but the fibrovascular bundles scattered through the pith also aid slightly in their support. Monocots and dicots belong to the phylum Spermatophyta. (8) Starfish: exoskeleton of bony or limy plates -- phylum Echinodermata. (9) Insect or crustacean: jointed exoskeleton of chitin and perhaps lime, covering the body completely -- phylum Arthropoda. (10) Vertebrate: internal skeleton of bones -- phylum Chordata. The ferns may be considered to have more complex skeletons than the snail or the oyster because the fern skeleton is made up of separate cells and because the fern skeleton runs through the entire body of the plant.

Problems, p. 238. 1. The fish has a "streamlined" body with no projecting limbs; it has overlapping scales, a slimy covering, fins, a powerful tail. It is usually protected by its ability to move rapidly and by its protective coloration. 2. To an enemy above, the eggs present a black surface which blends with the bottom of the stream; from below they are light in color like the sky above. This adaptation is another example of protective coloration. 3. Both metamorphoses have several distinct changes in form. There is no resting, or pupal, stage in the frog. 4. A smooth surface would afford nothing against which the ribs and the scutes could push to produce movement. 5. If it has scales, it is a lizard; if the skin is smooth, it is a salamander. A lizard has movable eyelids, while a snake does not. 6. This list will differ greatly for different parts of the country. 7. No key is possible for this question. 8. The legs of animals that live in trees usually have claws which assist in climbing. A squirrel or raccoon uses its front feet for holding food as well as for locomotion. A flying squirrel has a fold of skin stretched between the front and hind legs, enabling it to glide through the air. Other modifications of the legs of mammals are (1) the long slim legs of running animals like the deer; (2) the broad padded feet of the camel, which enable it to walk on sand without sinking in; (3) the short heavy legs of the hippopotamus, which are adapted more for life under water than on land; (4) the flippers of the seal, which are modified legs useful for swimming. (See also page 234.) 9. The joints of the skull, while immovable, are somewhat more flexible than a solid bone would be. A severe blow might crack a solid bone more readily than a skull of bones jointed together. Also, if the bone were cracked by the blow, the crack would probably not extend beyond the section which was struck. 10. Similarity: Both protect delicate structures. Differences: The shell of a turtle is made up of plates of modified epidermis which, along the back, has become firmly united with the backbone. The legs and head, however, are not covered with such a firm covering, but only with scales. The insect's exoskeleton covers the entire body. 11. Lobsters, prawns, shrimps, crayfish (all belong to the phylum Arthropoda); oysters, clams, snails, squids (all belong to the phylum Mollusca). 12. (1) Fossils have been found of animals very different from those existing today. It is thought that such great changes occur only over a great period of time. (2) Dinosaurs, now extinct, once existed in great numbers. (3) The earliest mammals were small and very different from those now existing.

Figure, p. 239. No, a snake could not move in the way pictured, because it would not have sufficient surface on the ground to furnish traction; also its backbone and ribs could not bend as indicated unless the coils were supported at each bend. Scientific attitudes 7, 11, 13.

Exercises on Scientific Method, p. 239. 1. Divide into two equal groups a number of people who have no warts on their hands. Allow all the members of one group to handle toads freely, while the members of the other group, who act as controls, do not. After two or three weeks examine the hands of both groups to see if they have warts. After a month or so reverse the procedures with the two groups, allowing the group to handle the toads who did not handle them before, and use the first group now as controls. 2. Many organisms which live entirely in the water have no skeletons, but are supported by the water. They are less dense than the water, therefore tend to float. 3. The environment may have changed so that they were no longer fitted for it; or were no longer able to find sufficient suitable food; or their enemies may have become more numerous; or new kinds of enemies may have appeared; or they may have become so specialized that it was impossible for them to adjust to a changing environment.

Exercise on Scientific Attitudes, p. 240. 1. No, the rattlesnake is resting on a cactus. Scientific attitudes 3, 7, 11, especially. 2. Scientific attitudes 3, 4, 5, 7, 8. 3. No competent observer has ever reported a snake which has a sharp poisonous spine on the end of its tail. The method of locomotion of all known snakes makes impossible that which is attributed to the hoop snake. No poisonous snake is known which has any poisonous weapon other than fangs in its mouth. Scientific attitudes 3, 7, 8, 10.

Figure, p. 243. Cattails, rushes, arrow leaf, sedges, algae; frogs, fish, turtles, water snakes, water insects, snails, etc.

UNIT IV

Unit Objectives: (1) To make clear the constant effort which man must make to develop the living things which are useful to him and to reduce the numbers of those which are harmful to him. (2) To make clear the great need for conservation of natural resources and the best methods of achieving it. (3) To encourage pupils to learn and practice the principles of conservation. (4) To reveal the social implications of conservation as it relates to the future welfare of the nation. (5) To lead pupils to appreciate the social implications of conservation as it relates to our growing problem of leisure time.

Chapter XIII

Figure, p. 247. Air and water are necessary to life; the high temperature and perhaps poisonous fumes from the volcanoes and fumaroles (crater-like vents) would make life impossible. Possibly the proportions of oxygen and carbon dioxide may also have been unfavorable to plant and animal life.

Experiment 41, p. 247. You will find small pebbles, perhaps flakes of mica, bits of quartz, and pieces of decaying plant bodies, such as leaves and stems.

Figure, p. 248. When the plants die, their bodies are added to the soil as humus. Many such regions which once were swamps are now cultivated fields. In most parts of the country examples may be found of bogs or lakes that are being filled in the manner shown in the figure.

Figure, p. 249. The lady's-slipper needs acid soil and certain conditions of shade. The list of native wild flowers facing extermination will vary greatly with the locality. There is probably no region in which some good illustration cannot be found.

Experiment 42, p. 249. You will find small round growths on the roots of the leguminous plants, such as clover and alfalfa, peas, and beans, but not on dandelion or grass. In these growths, called nodules, many bacteria grow.

Figure, p. 250. Every plant uses nitrogen compounds from the soil to build protoplasm. (Protoplasm contains the elements carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur, and frequently others.) If the plant dies, bacteria of decay and other soil bacteria reduce the complex compound protoplasm to simpler nitrogen compounds which can be used by other plants. If an animal eats the plant, the plant protoplasm is changed into animal protoplasm; if then the animal dies, soil bacteria reduce the nitrogen-containing matter in its body to nitrates. The same process occurs with animal wastes. The only way in which the element nitrogen can be used is through the action of the nitrogen-fixing bacteria on the roots of legumes. These bacteria combine free nitrogen from the air with other substances to produce nitrogen compounds, which the legume can use, or which are added to the soil when the plant or its roots die and decay.

Figure, p. 252. The soil on which the house stands is being washed away by water when it rains, because there are not enough plant roots to anchor it.

Figure, p. 254. Strip cropping (explained in the text) is used on the plains to reduce wind erosion. Terracing is used on sloping land where the slope is too rapid to permit ready cultivation or where danger of run-off down a slope needs to be lessened. Wind breaks have been used successfully in the plains regions. Improvement of roadsides includes tree and shrub planting, concrete or stone facings on steep grades along a new road, prevention of roadside gullies, etc. Improvement of stream banks checks the meandering of streams and thus prevents them from carrying away the soil. Check dams are used in regions where gully formation has just begun, and serve to hold the soil. Gully control may sometimes be secured by building small dams of logs, stones. or brush, which slow down the rate of run-off and promote the deposition of soil behind the dam. Listing consists in plowing in such a way that ridges of soil are left on the windward side of the furrows; the wind then will move the soil into the furrows.

Figure, p. 255. The soil was used only for growing corn or wheat, and therefore was bare much of the year. Annual plowing kept it loose, lack of rain made it dry, and wind blew much of it away. The poor subsoil would not support crops. It is being reclaimed by planting close-growing grass crops, by strip cropping, and by plowing under certain green crops to increase the humus content of the soil.

Self-test, p. 256. 1. Change fertile to rocky. 2. Change little to no. 3. Transpose valleys and hills. 4. See page 253. 5. Change few to no (because fish must have the minerals which water washes out of the soil). 6. See page 249. 7. Crop rotation. 8. Irrigation.

Figure, p. 257. No, since the heavily shaded areas indicate that there are enormous numbers in some regions; also, the fact that it is spreading to new regions shows that the present balance will be upset there.

Figure, p. 258. Complete.

Figure, p. 259. The eggs are laid in the body of the larva of the tomato worm. The larvae of the parasite hatch and feed upon the tomato worm. When the larvae of the parasite get ready to pupate, they eat their way through the skin of the tomato worm and spin their cocoons on the outside. It is not uncommon to find forty or more on one tomato worm. In this way the parasitic insects help by destroying the tomato worm.

Figure, p. 261. One can obtain this information from the Department of Agriculture bulletins on the scale insects; also, the state agricultural experiment station usually provides the needed information.

Figure, p. 262. The cicada will prove especially interesting for a special report, since its larva remains underground for periods of from two to seventeen years, depending on the particular species studied.

Self-test, p. 263. 1. Change small to great. 2. (See the list on page 263.) Additional methods are quarantining infected areas and quarantining and inspecting products received from foreign countries. 3. (1). (The ladybird beetle is not a pest.) 4. Change many to one and victories to victory. (Or change many to no, since the pest has not been exterminated but merely controlled.)

Self-test, p. 264. 1. (2). (The others are pests which attack animals.) 2. See page 264.

Figure, p. 266. See pages 265-266.

Figure, p. 267. The corn smut does not have an alternate stage in other host plants, as wheat rust does. Both are fungi, which produce spores that are distributed by wind.

Self-test, p. 268. 1. (5). (Plant lice are not plants, as are all the other parasites named.) 2. R. 3. (5). (This is a parasite; the rest are hosts of parasites.) 4. Change seeds to spores. 5. Change saprophytes to parasites. 6. Rusts.

Self-test on Biological Principles, p. 268. 1. Soil bacteria make nitrates which the plants use in manufacturing proteins. Animals use the plant proteins or other animals which have eaten plant proteins. 2. Man and the insects are constantly competing for the limited amount of available food. Whichever is more successful will ultimately survive, and the other will become extinct.

Problems, p. 268. 1. Tapeworm, liver fluke, malarial parasite, wheat rust, apple rust, white-pine blister rust. 2. Because nearly always there are plants growing in soil. Alluvial soil, moreover, would contain many different kinds picked up by the agents of erosion (wind or flowing water, glaciers, etc.) which deposited the alluvial soil. 3. Cacti need dry, sandy soil; onions require rich muck for their best development; peanuts grow best in sandy soil; etc. 4. The bacteria feed on organic matter in the soil. 5. There is more humus and other organic matter near the surface. 6. Ichneumon-fly larvae on the tomato worm are parasites. Birds, toads, frogs, skunks, snakes, ladybird beetles, eat the pests. 7. To afford humus. The practice of permitting plant materials to remain on the ground is undesirable in case the decaying plants harbored undesirable pests, as is the case in cornfields which are infested with corn-borer. 8. Some are useful and some are harmful. Whether they are useful or harmful depends upon whether they themselves can be used by man or whether they harbor or feed other organisms useful to man. Whether they are harmful depends upon whether they themselves spread as pests and whether they harbor or are fed upon by other pests. 9. Saprophytes, because they feed only upon dead organisms. 10. Symbiosis, because they find a suitable habitat in the roots of the legumes and furnish nitrates as foods for the legumes.

Exercise on Scientific Method, p. 269. 1. He inferred that the powder with which he dusted the vines killed the organisms which caused disease. 2. The controls were the vines which were not along the road, and which were not dusted.

Chapter XIV

Figure, p. 271. Walls slow down the rush of water and help to hold soil which accumulates behind them.

Figure, p. 272. Game laws, and reserves such as parks and sanctuaries. The biological principle is protective coloration, which may be stated thus: "Some animals may escape their enemies because they have body colors or other characteristics which make them difficult to see in their habitat." There are six partridge chicks in the right-hand picture.

Self-test, p. 272. 1. Change no to proper or a similar word. 2. Cutting of timber and damage by fire, fungi, and insects. 3. Transpose increasing and diminishing. 4. Source of wood for lumber and for wood-pulp industries; source of by-products, such as turpentine and sugar; regulation of water flow thus diminishing floods and controlling erosion; home of wild life. 5. Change forbidden to encouraged.

Figure, p. 273. Lumber is destroyed; standing trees are damaged; young trees are killed; the humus is burned from the soil.

Figure, p. 275. Try to educate people through the medium of newspapers and radio so that fewer incendiary fires will be started. Use these means, as well as signs in the forests, to warn campers and smokers of their responsibilities. Urge lumbering companies to remove debris in which fires may start. Demand that trains traveling through forested areas have spark-arresters.

Self-test, p. 275. 1. (1), though many pupils may choose (4) correctly, since man is largely responsible for the fires. 2. Change all to some or considerable. 3. Change large to small. 4. R. 5. R.

Figure, p. 277. Trees thickly planted prune themselves; that is, the lower limbs die for want of sufficient sunlight and fall off, with the result that the stems are free from limbs and knots for a considerable length.

Figure, p. 278. By education of the public, carried on in newspapers, over the radio, by cartoons and posters, by exhibits in museums and at fairs, etc.

Figure, p. 280. The gull eats refuse from the lakes, rivers, and harbors.

Figure, p. 281. (See page 281) The list of birds will vary with the locality. It includes many of the common birds in any region.

Figure, p. 282. Because they feed on such things as weed seeds during the entire winter.

Figure, p. 283. "Many living things prey upon other living things in the constant struggle for energy." "Every organism has its enemies." "Organisms which prey on other organisms help to maintain the balance of nature."

Figure, p. 285. Wild birds soon learn to use these specially protected regions. The Audubon Society has members throughout the United States, all interested in protecting birds. The society is named for a great student and painter of birds, John J. Audubon.

Self-test, p. 286. 1. Weeds. 2. Change rodents to weed seeds. 3. Change will to may. 4. R. 5. Change all to some.

Figure, p. 287. Beaver dams help to check erosion and build up soil; the fur is valuable.

Figure, p. 288. (1) Because they were so important in the early history of our country; (2) later they may serve as a supply of meat and leather.

Figure, p. 289. Because snakes eat relatively little and not frequently; birds eat relatively a great deal and frequently. Also, there are fewer snakes than birds.

Figure, p. 291. Fish are now "planted" in the streams and lakes of practically every state where such bodies of water exist. The kinds used must be those which can thrive in the different regions.

Self-test, p. 291. 1. Change always to sometimes. 2. Rat. 3. Change meat to furs. 4. Fur. 5. Change ungulates to rodents. 6. Fur; check erosion; build soil above the dams.

Figure, p. 293. Only a small percentage of the young fish will grow to adult size. Many will be eaten by larger fish, birds, turtles, snakes, and other enemies.

Figure, p. 294. Most of the national parks are in the mountain regions, where the scenery is more majestic than in the plains regions. As appreciation of other regions develops, it is likely that there will be wider distribution of national parks.

Self-test, p. 294. 1. Change all to some. 2. Change fish to mollusk. 3. Oysters, clams, lobsters, as well as fish.

Figure, p. 295. Fish in the lake; large mammals, such as deer; wolves in the woods; birds in the forest or along the lake.

Self-test, p. 297. 1. Change Agriculture to Interior. 2. R. 3. See page 296. 4. See "Summary of methods of wild-life conservation," p. 297.

Self-test on Biological Principles, p. 298. Transpiration from forests increases rainfall, p. 271; man destroys forests, p. 272; insects and fungi are enemies, p. 274; birds eat insects, p. 281; etc.

Problems, p. 298. 1. A forest community includes all the plants and animals living in a given forest. 2. (1) The cutting or burning of the forest trees gives an opportunity and space for smaller vegetation to increase rapidly on the ground formerly covered by the forest; (2) birds and other animals which can live only in the forest must migrate to new forests or die. Their going causes their prey to increase and their enemies to decrease in number. 3. The forest offers opportunities for the study of wild life in their native habitats. 4. By planting tree crops on idle or low-value land. Such crops could be nuts or perhaps Christmas trees. 5. By planting the trees close together, so that the lower limbs die for want of sunshine and consequently for want of nourishment. 6. Forests furnish food and fuel, recreation, sometimes shelter. 7. Seeds of such trees have been widely scattered in places particularly favorable to these kinds. 8. This helps to hold in check the kinds of plants or animals that are reproducing most rapidly. 9. They consume most insects then in feeding their young. 10. By providing exact information regarding what should be encouraged and what discouraged. 11. Find what local needs there are to which attention can be directed. 12. Their food is secured at different places at different times. Also, their breeding places especially need protection because the continuity of their kind depends upon production of new individuals.

Exercise on Scientific Method (Making Inferences), p. 298. The bodies of large mammals include relatively more structures that do not have to be remade in a short period of time. For example, the bones are remade very slowly. Then the larger mammals live longer, as a rule, and utilize their food energy more slowly than the smaller mammals. Also, so much larger a proportion of the food eaten by small animals needs to be transformed into heat energy.

UNIT V

Unit Objectives: (1) To learn how different kinds of plants and animals secure and use their foods. (2) With Unit III as a basis, to make clear the principle "Complexity of structure goes hand in hand with division of labor." The fundamental processes related to food energy are developed from the simplest to the most complex organisms. (3) To give useful knowledge of physiology and hygiene.

Chapter XV

Figure, top of page 303. The pitcher plant's leaves contain water, in which insects may be drowned. The leaves of sundew and flytrap fold over insects and hold them. The leaves of carnivorous plants, after capturing insects, secrete liquids which digest parts of the insects' bodies.

Figure, bottom of page 303. "Life is a constant struggle against enemies" (struggle for existence). "Those organisms are most likely to survive which are best equipped for success in the environment" (survival of the fittest).

Figure, p. 304. Euglena can secure food in many different environments, and thus has a wide range of places in which it may live.

Figure, top of page 305. The protoplasm of the amoeba parted at the point where it touched the Euglena cyst, and engulfed it by flowing around the cyst.

Figure, bottom of page 305. Yes, locomotion.

Figure, p. 306. Protection from enemies.

Figure, p. 307. The numerous teeth form a rough surface that is effective in scraping food from sticks, stones, etc.

Self-test, p. 307. 1. R. 2. Change few to most. 3. Change the first all to no. (A few, like the mistletoe (p. 53), make part of their food and hence are called "partial parasites.") 4. Change the first all to no; and second all to any. 5. Change symbiosis to osmosis. 6. (3). 7. Sponge. 8. See "Summary," p. 306.

Figure, p. 308. The beetle has mouth parts resembling those of the grasshopper.

Figure, top of page 310. A (sucker) secures food from the river bottom; B (deep-sea fish) captures other fish as food.

Figure, bottom of page 310. Other amphibians.

Figure, p. 311. Toward the throat, to aid in holding prey and to force the prey toward the throat.

Figure, top of page 312. The heavy short beaks of the finch, the turkey, and the chicken are typical of seed-eaters. The beaks of the wren and bluebird are especially fitted for catching insects. The wide mouth of the swift is held open as it flies, to catch insects in the air. The bills of the crane and stork are long enough to reach under water for such animals as frogs, fish, or tadpoles. The flat toothed beak of the duck is used to scoop up mud and to strain the food particles from it. The hooked beak of the falcon is useful in tearing the flesh from its prey.

Figure, bottom of page 312. The rabbit has teeth used for gnawing or biting plant food. The bat has many sharp teeth useful for catching and crushing insects. The dog has well-developed canine teeth for tearing off bits of flesh. The horse has biting teeth for picking up food, and strong grinding teeth for breaking the food into smaller pieces. Man has teeth of several different kinds, a fact which indicates that he eats many kinds of food, which he chews thoroughly.

Self-test, p. 313. 1. Change few to most. 2. 1, c; 2, e; 3, f; 4, i; 5, a, c; 6, i.

Figure, p. 313. They are only temporarily a part of the organism; they are shed at a fairly definite time in the life of the organism.

Figure, p. 315. More food is needed to supply the energy used in exercising.

Self-test, p. 316. 1. Vitamins, water, and minerals. 2. Proteins, carbohydrates, and fats. 3. Change photosynthesis to metabolism. 4. Change no to some or considerable. 5. Change degrees to Calories. 6. Mechanical; heat. 7. Carbon dioxide and water.

Figure, p. 317. The lower three figures represent the fact that one gram of either protein or carbohydrate will raise the temperature of one kilogram of water 4.1° C., while one gram of fat will raise the temperature of 2.27 kilograms of water 4.1° C.

Experiment 43, p. 317. 1. Fehling's solution when added to grape sugar and heated gives a precipitate which is yellow, brick-red, or brown. Substances which contain no sugar give no such color when placed with Fehling's solution. 2. Iodine added to starch produces a dark-blue or purple color. Iodine added to sugar produces no color change. 3. Nitric acid added to protein produces a lemon-yellow color. The addition of ammonium hydroxide produces a bright-orange color. Nitric acid and ammonia produce no similar color changes with sugars, starches, or fats. 4. Fats produce translucent spots on paper, while sugars, starches, and proteins do not produce such spots. Scientific Method: The purpose of the controls is to show that only the test substances react in the ways observed. It is necessary to repeat tests on which individuals disagree, in order to discover what the facts really are. Even where all individuals agree, it is possible that all have made the same mistake in experimenting, and the result may be incorrect; hence great care in work is needed, and the results must be checked.

Figure, p. 318. Cake and frosting, candy, potatoes, pumpkins. The sugar and candy come indirectly from sugar cane, beets, or maple trees. The flour in the cake comes from wheat. The starch stored in the potatoes and the pumpkins was made by the potato and pumpkin plants by photosynthesis.

Figure, p. 319. Butter, lard, olive oil, fat meat, cream in the cheese. Others are peanut butter, nuts, vegetable oils (as cottonseed and corn oils), cream, etc.

Figure, p. 320. Milk; white of egg; lean meat, such as pork, beef, fish, fowl; cheese; beans. Others are peas, corn, nuts, and grains.

Figure, p. 321. In the flickering lights and shadows of their native habitat, protective coloration makes them less conspicuous than they would be if their bodies were of one color. "Protective adaptations are an aid in survival."

Figure, p. 324. The absence of any essential vitamin results in some kind of malcondition. Vitamin charts available in encyclopedias indicate the particular function of each vitamin.

Self-test, p. 324. 1. (4) more than twice. 2. (2) proteins. 3. Change protein to fat. 4. (2) cornstarch. 5. Change fats to proteins. 6. (1) olive oil.

Figure, p. 327. A: cream, oysters, prunes, lettuce. B: turnips, carrots, nuts, peas. C: cabbage, grapefruit, strawberries. D: milk, butter. E: milk, butter, nut meats. G: meat.

Figure, p. 328. Calcium in buttermilk, onions, cheese, cauliflower. Phosphorus in eggs, corn, peas, fish. Iron in oysters, peas, spinach, meat, prunes, raisins.

Figure, p. 329. Animals that do not drink get their water from the food they eat.

Figure, p. 331. Probably more cold foods would be served on a picnic than at home. The meat would be almost certain to be broiled. Cooked vegetables probably would be omitted. Instead of an elaborate salad, raw vegetables might be served.

Self-test, p. 332. 1. Vitamins, mineral salts, water, flavors and condiments, stimulants. 2. Change proteins to vitamins. 3. Change Calories to building materials. 4. Bread; milk. 5. Anemia. 6. (1) Supply water needed by the protoplasm, (2) transport substances, (3) dissolve foods and other substances. 7. Change children to adults. 8. Change tea to cocoa or chocolate. 9. Calcium, iron, sodium, iodine (or any others from page 327).

Self-test on Organization of Facts, p. 332. I. Essential foods. A. Energy foods. 1. Carbohydrates. 2. Proteins. 3. Fats. B. Non-energy foods. 1. Vitamins. 2. Mineral salts. 3. Water. II. Accessory foods. A. Food flavors. B. Condiments. C. Stimulants.

Self-test on Biological Principles, p. 332. 1. Certain cells of the sponge secure and digest food for the rest of the body. 2. "Summary," p. 306, and pp. 308-312.

Self-test on Making Comparisons, p. 333. 1. Have pupils contrast the starfish with various other organisms in turn and prepare comparisons according to the instructions, pp. x-xi. 2. Similarities: Both independent and dependent plants absorb liquids by osmosis. Differences: Dependent plants absorb digested food and other needed materials directly from the phloem of the host plant.

Figure, p. 333. The third type of enemy.

Problems, p. 333. 1. Milk, eggs, alcohol, secretions of plant lice. 2. The tube feet are extended by being filled with water. When they press firmly against a surface, some of the water may be withdrawn, leaving a suction cup at the tip of each foot. The pressure of the water outside the foot is now greater than the pressure inside the cup, and so helps to hold the foot against the shell. 3. Garter snakes and green snakes eat insects; black snakes eat birds' eggs, birds, and other snakes; most snakes eat amphibians; black snakes and gopher snakes eat rodents. These are only sample answers of the kind your pupils may give. 4. The woodpecker has a long, heavy beak used in digging into wood to secure boring insects. The humming bird has a very long, narrow beak which extends into flowers, thus enabling the bird to secure nectar. The beak of the crossbill is twisted in such a way that it can more easily pry apart the scales of pine cones and thus reach the seeds which it eats. The turnstone, which is a wading bird, has a bill which curves upward, enabling it to reach under stones for worms or insects. The beak of the woodcock is sensitive and movable at the tip, making it possible for the bird to probe and feel in the mud for the worms on which it feeds. 5. This list will vary widely for different localities. 6. Roots: beets, turnips, carrots, parsnips. Stems: asparagus, potato. Leaves: lettuce, cabbage, kale. Leaf petioles: rhubarb, celery. Buds and Flowers: Brussel's sprouts, cauliflower, broccoli. Fruits: berries, melons. Seeds: nuts, grains. 8. Milk lacks some necessary minerals, especially iron, and also lacks certain of the amino acids. 9. People living in cold climates eat fat for its high heat value; in warm climates people avoid fats. The layers of fat, or blubber, on arctic animals serve as insulators to retain the body heat. 10. Animals which have been discussed in this chapter and which move about in search of food are Euglena, Amoeba, Paramecium, earthworm, snail, crayfish, insects, fish, reptiles, birds, and mammals. Most of the animals higher in the scale of life than mollusks, as well as many lower animals, belong in this class. Kinds of animals which remain stationary and capture whatever food comes near are sponges and Hydra. Other animals belonging in this class are mollusks, such as the oyster and the clam, and such body parasites as tapeworm and hookworm; also many Protozoa such as Vorticella and other stalked forms. 11. In all three ways.

Exercises on Scientific Method, p. 334. 1. The earthworm makes a partial vacuum within its mouth; the greater air pressure outside its mouth then forces earth containing food into its mouth. 2. A caterpillar eats leaves; the adult butterfly eats plant nectar. During the pupal stage, therefore, the mouth changes from one having biting parts to one having a sucking tube.

Exercise on Scientific Attitudes, p. 334. Especially 3, 5, 9, 11, 12.

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Figure, p. 337. The rooting section stimulates the team to action without actually taking part in the game. An enzyme causes digestion to go on without being used up and without taking part in the chemical changes which it stimulates.

Self-test, p. 337. 1. R. 2. Change vitamin to enzyme. 3. Digestion. 4. Change increase to decrease. Ice water might lower the temperature of the contents of the stomach below 40°-50° C., that is, below the temperature at which the enzymes are most effective.

Figure, p. 338. During the summer the leaves of the tree manufacture starch by photosynthesis. This starch is digested to sugar in the leaves and is transported to other parts of the tree, which it nourishes. The excess sugar is transformed to starch by enzymes and is stored in the roots or other structures. It remains in this form through the winter. When the stored food is needed to supply food for the developing buds in the spring, the starch is again changed, or digested, to sugar and is transported upward through the xylem. If these conducting tubes are tapped, one can obtain the sweet sap.

Experiment 44, p. 338. Both dry seeds and germinated seeds will show starch, but only the germinating seeds will show the presence of sugar.

Experiment 45, p. 338. Diastase will change starch to sugar, as shown by the fact that the tube to which diastase was added gives the sugar test but not the starch test. Scientific Method: The control in this case was the tube containing starch and water. It was used to show that the warm water alone was not responsible for the digestion of the starch in the second tube.

Figure, p. 339. The separate cells of the inner layer of the sponge secure and engulf food much as does the amoeba. Digestion is then carried on by means of enzymes within each cell.

Figure, top of page 340. Within the gastrovascular cavity and within the separate cells lining this cavity.

Figure, bottom of page 340. Tapeworm and liver fluke.

Figure, top of page 341. The earthworm has a highly specialized food tube with a crop and a gizzard; the earthworm has a more highly specialized mouth and pharynx than the flatworm.

Figure, bottom of page 341. The crayfish has complex mouth parts, a stomach in two specialized parts, and a liver (called hepato-pancreas).

Self-test on Organization of Facts, p. 341. 1. Certain Protozoa. 2. Sponge: phylum Porifera. 3. Hydra: phylum Coelenterata. 4. Flatworm: phylum Platyhelminthes. 5. Earthworm: phylum Annelida. 6. Frog: phylum Chordata.

Figure, top of page 342. Both have mouth, esophagus, crop, gizzard, and intestine. The grasshopper has a stomach.

Figure, bottom of page 342. The same organs are found in the digestive system of the frog and man. In man the intestine is much longer and is more definitely coiled.

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Self-test, p. 343. *1*. Change *part of the* to *all*; change *inside* to *outside*. *2*. Change *vitamins* to *enzymes*; change *proteins* to *sugars*. *3*. Change *protoplasm* to *enzymes*; add *carbohydrates* or *starch*. *4*. Change *certain* to *no*. *5*. Change *few* to *all*. (The only animals which are exceptions are those parasites that absorb digested food.)

Figure, p. 343. The saliva is poured into the food at various points and thus is more readily and surely mixed with it than would be possible if all the saliva were secreted by one large gland.

Experiment 46, p. 343. The corn-starch tastes sweeter. This change is due to the action of the saliva in digesting the starch and changing it to sugar. *Scientific Method*: All the test tubes were kept in the same surroundings; all were tested soon after the liquid was added. The factor that was different was that the control had warm water added in place of saliva. The control was necessary to prove that the saliva was the factor which really made the difference.

Figure, p. 344. The alimentary canal is merely a passage through the body, in which food can be digested. By some persons digested food is not considered to be truly within the body until it has passed through the walls of the small intestine. There may justly be differences of interpretation on this point.

Experiment 47, p. 345. The egg to which water only is added shows no change in appearance. In the tube to which the pepsin is added the liquid becomes slightly milky. The tube to which hydrochloric acid is added shows no change. But in the tube which contains both pepsin and hydrochloric acid in water the liquid is very milky and the solid egg white completely disappears.

Figure, p. 346. Starch is digested in the mouth; proteins are digested and fats are partly liquefied in the stomach; all the nutrient foods are digested in the intestine.

Self-test, p. 347. *1*. Under the tongue, on the insides of the lower jaws, and in front of the ears. (Some pupils will wish to learn the names as well as the location.) *2*. To moisten the food, to dissolve dry food, and to digest starch. *3*. Change *protoplasmic* to *peristaltic*. *4*. Change *protein* to *starch*; change *starch* to *sugar*. *5*. Softens tissues of food; kills bacteria; prepares protein for digestion. *6*. Change *starch* to *fats*. *7*. Change *fats* to *starches*.

Experiment 48, p. 347. The substances which are most effective in making fats into an emulsion are water and some such alkali as ammonia or lye. (The purpose of this experiment is to show the action of the alkaline secretion, bile, in preparing fats for digestion.)

Experiment 49, p. 348. Pancreatic juice will digest emulsified fat, protein, and starch. It contains special enzymes which act on each of these. *Scientific Method*: Each test tube of a pair or group acts as a control for the other; for example, the tube containing only protein and warm water acts as a control on the tube containing pancreatic juice mixed with the protein and water, because it involves all the same factors except the pancreatic juice. The food substance to be tested was the same in each pair or group of test tubes. In each pair all the factors were the same except the one which was being tested; for example, the pancreatic juice in Experiment 49 is the experimental factor.

Figure, p. 349. To secrete pancreatic juice; the islands of Langerhans are ductless glands secreting insulin. This last function, however, probably need not be mentioned at this time unless specific questions from pupils make it necessary.

Figure, p. 350. Peristalsis is described on page 346.

Figure, p. 352. Less rapid, because not so much food would be likely to get into the pit and that which entered the pit would remain there for a longer time, possibly in an only partially digested state. (The rounded mount in the illustration on the left is one of a great number of similar organs in the intestine, which manufacture white corpuscles).

Self-test, p. 352. 1. To complete the digestion of food; to provide surface for absorption of food. 2. Pancreatic juice, from the pancreas; bile, from the liver; intestinal juice, from many small glands in the walls of the small intestine. 3. Change photosynthesis to peristalsis.

Figure, p. 353. While food is in the small intestine, time is needed to permit complete digestion and considerable absorption. In the large intestine, water and digested food are absorbed.

Self-test on Biological Principles, p. 353. 1. Any of the animals that are more complex than the sponge may be used to illustrate the principle. For example: the earthworm is a fairly complex animal. It has a digestive system consisting of several parts, each of which does some of the work of digestion. 2. The cells of the inner layer of the sponge digest food for other cells of the body. In the amoeba or the paramecium, each of which consists of only one cell, division of labor is not possible. 3. One enzyme cannot digest every kind of food. Instead there is a different enzyme or several enzymes to digest each class of food.

Problems, p. 353. 1. Alkaline, because starch is also acted upon in the mouth, where the saliva is alkaline. 2. No, the bacteria cannot make part of their own food, as can the mistletoe; they usually do no damage to the host, such as would result if they destroyed tissues. 3. In the mouth the food is broken up into small pieces by the action of the teeth and is moistened by the saliva. At least part of the starch in the bread is changed to sugar by the action of the enzyme ptyalin. Then all the food goes to the stomach. Here the milk is acted upon by the rennin. The meat is partly digested by the action of the enzyme pepsin in the gastric juice. The cream and any fat meat are acted upon by gastric lipase and partly digested. Food then passes on into the small intestine, where all the food substances which have thus far escaped digestion are acted upon by the enzymes of the pancreatic juice, bile, and intestinal juice. For details see pages 348 and following. 4. The enzymes act more effectively in a warm medium. Ice-cold milk will delay the action of the digestive enzymes. 5. Food is less likely to be forced into the windpipe by the entering air. 6. Green plant cells usually have walls of cellulose, which is very difficult to digest. A long intestine will permit the digestive juices to act on the food for a greater length of time.

Exercises on Scientific Method, p. 353. 1. a. The crayfish will be more thoroughly digested by the frog that was kept in the warm room. Since the frog is a cold-blooded animal, its body temperature varies but little from that of its surroundings. Accordingly when one frog was placed in the ice chest, its body temperature sank to a point where the digestive enzymes were less active than normally. b. (1) The Protozoa digest the food, forming products which can then be used by the termites. (2) Certain products given off by the Protozoa assist in the digestion and absorption of the wood by the termites or are otherwise necessary to the existence of the termites. Apparently there is a symbiotic rather than a parasitic relation between the termites and the Protozoa. 2. Place a small amount of starchy food, such as cracker, in a test tube; in another place a small amount of protein, such as cooked egg white. Add a small quantity of saliva to each tube, and put in a warm place for fifteen minutes. Test the first tube for starch, and the second for protein. Has either been changed, that is, digested, to some other substance?

Exercise on Scientific Attitudes, p. 354. Especially 1, 6, 7, 8, 9.

Chapter XVII

Figure, p. 356. He must secure water, fresh plant foods, and meats. He can carry canned or dried fruits, dried vegetables, salted meats, and various manufactured foods, such as crackers or chocolate.

Figure, p. 358. Food, oxygen, and probably water.

Self-test, p. 359. 1. Change most to none. 2. R. 3. (1), (2), (3), (4), (5). 4. To carry hormones and antibodies; to fight disease germs; to carry carbon dioxide from the cells.

Figure, top of page 360. Water which is absorbed by the roots is transported upward through the xylem tubes of the root, stem, and leaf. The upward flow of the water is due to the effects of a combination of root pressure, transpiration, imbibition and capillarity, also partly to causes not yet known. Manufactured food is transported from the leaves downward through the phloem tubes of the leaves, stems, and roots. The xylem and the phloem tubes are never directly connected with one another; that is, the phloem and xylem systems are separate.

Figure, bottom of page 360. The amoeba has no circulation except that of the protoplasm itself. In the sponge, digested foods can be passed from one cell to another by osmosis. In Hydra, food which has been digested in the gastrovascular cavity may be caused to circulate in this cavity and can therefore be secured by any of the inner cells. The flatworm has an intestine which is greatly branched. Food passes from these fine branches to the cells.

Figure, top of page 361. It has a definite organ, the heart, which is concerned solely with the circulation of blood.

Figure, bottom of page 361. It has blood vessels both for carrying the blood away from the heart and for returning blood to the heart; that is, the earthworm has a closed circulatory system.

Experiment 50, p. 362. In the web of the frog's foot one may observe the branching capillaries; also, one may distinguish blood vessels, probably arteries and veins, in which blood is traveling in opposite directions. In the capillaries the oval red blood cells pass through in single file. In the larger blood vessels the blood cells pass more rapidly. An advantage in having the blood move more slowly in the capillaries is that the slower speed makes possible a greater transfer of food and oxygen to the body cells. The red blood cells (which usually appear more yellow than red) are easily seen. Probably none of the pupils will find white blood cells unless they prepare microscope slides of the blood. As a rule the white blood cells in the frog are smaller than the red ones.

Figure, p. 363. The functions of B represented in A are (1) the transportation of food and fuel (food, coal, and oil trucks), wastes (garbage wagons), hormones (messenger boys), and disease-combating substances (army), (2) the policing activities of certain cells (single soldiers). The function of the circulatory system which cannot be represented is the distribution of heat throughout the body.

Figure, p. 364. The hearts of the earthworm are merely enlarged blood vessels and have no special heart structures. The fish has one auricle and one ventricle. The amphibian has two auricles, but only one ventricle. The reptile has a partly divided ventricle. The bird and the mammal have the ventricle completely divided, forming two ventricles as well as two auricles.

Self-test, p. 365. 1. Osmosis. 2. R. 3. Vascular system of tubes placed end to end; open vascular system; and closed vascular system. 4. Change Hydra to earthworm. 5. Change higher to lower. 6. Change mammals to birds.

Figure, top of page 366. Capillary walls are only one cell thick. The walls of arteries and veins each consist of three layers. The muscular layer is much thicker in an artery than in a vein.

Figure, bottom of page 366. Valves prevent the blood from flowing backward.

Figure, p. 367. The diagram and its labels provide ample guides for tracing the blood from and to the different organs.

Figure, p. 369. The blood pressure of a boy of seven is sufficient to support a column of mercury about 85 millimeters high; that of a boy of 15, to support about 115 millimeters of mercury; etc. The pressure in a vein is only about $\frac{1}{16}$ to $\frac{1}{8}$ that in an artery.

Experiment 51, p. 369. The heart beats more rapidly when one exercises violently or even when one stands than when one lies down or sits quietly.

Figure, p. 370. The lymphatic system is a one-way system, carrying fluid back toward the heart only. Since the tubes begin as open spaces, it resembles an open vascular system more closely than it resembles the closed vascular system of blood tubes. The fluid carried does not contain red corpuscles; white corpuscles that have escaped from the blood stream may be found in lymph; lymph contains much waste material gathered from the cells.

Self-test, p. 371. 1. R. 2. Transpose arteries and capillaries. 3. Change blood to lymph. 4. Change circulatory to lymphatic; change chest to neck. 5. Change blood to lymph. 6. Suppose you begin at the end of the middle finger. The blood flows from a capillary into a vein, thence to a larger vein, to a still larger vein, till it reaches the right auricle of the heart. From there it passes to the right ventricle, through the pulmonary artery to the capillaries of the lungs, thence back through the pulmonary vein to the left auricle of the heart, then to the left ventricle and out through the aorta, through smaller and smaller arteries, until it again reaches the finger. 7. R.

Experiment 52, p. 372. The liquid part of the blood is colorless or yellowish; the red blood cells appear yellow. White blood cells are transparent, larger than the red cells, and of less definite shape than are the red. (Refer to the figures on pages 363 and 374.)

Figure facing page 372. See pages 367-368; also the answer to question 6 in the self-test on page 371.

Figure, p. 373. More energy is needed in the muscles; therefore more food and a greater supply of oxygen to oxidize the food are needed. More rapid beating of the heart is necessary to ensure that more blood carrying these necessities shall reach the cells.

Figure, p. 374. The smallest blood cells shown in the figure on page 363 are the blood plates.

Figure, p. 375. The artery brings to the villus the blood which supplies oxygen and food. The vein takes absorbed food away, also the wastes from the cells composing the villus. The capillaries absorb digested proteins, starches, and sugars. The lacteal absorbs digested fats and carries them into the lymphatic system. The mucus glands secrete the fluid which keeps the surface of the villus moist.

Figure, p. 376. Because more energy is needed, and energy can be released in the body only through the oxidation of food.

Self-test, p. 377. 1. Change red to clear; change lymph to plasma. 2. 1, e; 2, b; 3, c; 4, h; 5, i; 6, j; 7, d. 3. Change plasma to lymph. 4. Assimilation. 5. See "Summary of processes having to do with the use of food," pp. 376-377.

Self-test on Biological Principles, p. 377. 1. Foods are usually of insoluble form when they are taken into the body. They must be digested, that is, acted upon by enzymes and reduced to soluble forms. Then it will be possible for food substances to be circulated to all the cells and used by the protoplasm. 2. All the plants or animals discussed in the chapter will serve as satisfactory illustrations.

Problems, p. 378. 1. The green ink enters the xylem tubes of the stem along with water. It is carried into all the small veins of the petals (which are really modified leaves). 2. The grasshopper and the crayfish both belong to the phylum Arthropoda. 3. The open vascular system. 4. Yes, the corpuscles, and the cells making up the walls of the blood vessels. 5. When one is standing, the heart has to pump hard enough to force the blood in the veins upward from the lower parts of the body. When he is lying down, the blood flows back to the heart more readily. 6. There is more time for the food and oxygen to pass from the blood stream to the surrounding lymph and for wastes to pass from the body cells into the blood. 7. The left ventricle pumps blood all over the body. Hence it must be more muscular than the right ventricle, which pumps blood only to the lungs. The auricles pump blood only into the ventricles and therefore do not have as strong walls as those of the ventricles. 8. The circulatory system is a closed series of tubes, with vessels extending from the heart and back to it; the lymphatic system consists of tubes, open at one end, which lead only in the direction of the heart. In the circulatory system, the fluid contains white and red blood corpuscles; in the lymph, there are only white corpuscles. 9. The pulse and peristalsis are both wave-like movements in the walls of a tube. They differ in that the pulse is caused primarily by the contraction of the heart and the resulting wave of blood pushing against the arteries, while peristalsis is due to the successive contractions of the walls themselves. 10. Inorganic substances, such as compounds of iron, phosphorus, calcium, sulfur, potassium, and iodine. Organic substances, such as digested proteins in the form of amino acids. 11. The valves are pockets which fill with blood when for any reason the blood is forced backward. Thus they prevent blood from continuing to flow backward, and the pressure of more blood coming on from the heart keeps the blood flowing in the same direction. 12. Parasitic flatworms like the tapeworm are surrounded by digested food and absorb it through the body walls. 13. In the pulmonary veins the blood contains much oxygen and little carbon dioxide because this blood is returning to the heart from the lungs. In other veins the blood contains little oxygen and more carbon dioxide. 14. When one exercises he uses more energy. Oxygen is needed in the cells to release energy from assimilated food. The heart must therefore beat faster in order to send more blood to carry oxygen to the cells. 15. In the upper right of B on page 363 there is a white blood cell forcing its way out between two cells in the wall of the capillary.

Exercise on Scientific Method (Evaluating Procedures), p. 378. No conclusion which is true of people in general could be arrived at from observations of only one person. Even when many people are observed in this experiment, the data are not exact, because the conditions causing the fear, excitement, etc., are different, and the observers' interpretations of these states are different.

Exercise on Scientific Attitudes, p. 379. Chiefly attitudes 5, 9, 10.

Chapter XVIII

Figure, p. 381. The amoeba and the engine both take in oxygen, use it to release energy from food or fuel, and give off carbon dioxide. Both also eliminate water which results from oxidation of food or fuel.

Experiment 53, p. 381. 1. In the jar in which the plant was growing, the limewater has a white film floating on its surface. This film is made up of particles of calcium carbonate, proving that carbon dioxide was present in the jar. The other dish of limewater was still clear. 2. The seeds grow best in the jar which is open to the air.

Scientific Method: The control in the first part of the experiment was the jar in which there was no plant. Identical factors were the soil, the dish of limewater, the air in the jar, the covered jar. The experimental factor was the plant. In the second part of the experiment some of the seeds in the sealed jar may grow, because there was some air in the jar before it was sealed, which may have supplied enough oxygen for them to start growth. The oxygen might be removed from the air in the jar by burning phosphorus in it.

Figure, p. 382. The experiment helps to prove that respiration takes place in all green plants because it furnishes an example of a green plant in which respiration occurs; but it does not finally prove this fact, since only a bean was used. For other experiments use the same method, but use other plants than the bean.

Figure, p. 383. A young stem is growing and requires more oxygen to release needed energy. Then, too, a young stem may carry on photosynthesis, and the numerous lenticels would serve to admit carbon dioxide, used in the process.

Self-test, p. 383. 1. To supply oxygen to every cell; to remove carbon dioxide from every cell. 2. Change lungs to cells. 3. Change transpiration to osmosis. 4. Stomata and lenticels. 5. Change some to all. 6. Change most to all; change lower to higher.

Figure, p. 384. The protozoan and both layers of the sponge are constantly bathed in water containing dissolved oxygen, which can enter every cell directly by osmosis.

Figure, p. 385. The numerous long gill-rakers serve to retain in the mouth cavity the small plants and animals that otherwise would pass out with the water current. A fish that feeds on large animals would have no need for such long gill-rakers. The blood vessel labeled "Artery from heart" corresponds to the pulmonary artery in man.

Self-test, p. 385. 1, g; 2, e; 3, b; 4, b; 5, b.

Figure, p. 386. The earthworm absorbs oxygen by osmosis through the moist skin. The snail has a simple lung (see page 387). The grasshopper has ten pairs of spiracles, and a network of air tubes throughout the body. With respect to most of their structures these animals, from simplest to most complex, are earthworm, snail, and grasshopper. However, with reference to complexity of their respiratory structures their order is from earthworm to grasshopper to snail. These three animals therefore furnish an exception to the general principle, in so far as their respiratory structures are concerned.

Figure, p. 387. The frog uses its nostrils as air passages and uses the tongue and the floor of the mouth to push air into the lungs. The fish takes in water through the mouth; then closing the mouth, it forces or swallows the water over the gills and out past the operculum. A good description of breathing in the frog is given on page 387.

Figure, p. 389. In addition to the divisions of the respiratory system itself (names beside the figure) the structures labeled are hard palate, soft palate, adenoid, tongue, tonsil, esophagus, tracheal cartilages.

Self-test, p. 389. 1. Change mouth to skin. 2. Lungs. 3. (1) mollusk. 4. R. 5. Fish.

Figure, p. 391. A many-branched lung provides much more surface for the exchange of oxygen and carbon dioxide than would a solid mass of tissue.

Figure, p. 392. Both lungs and gills are much divided, or branched, structures. They contain many capillaries enclosed in a thin-walled moist membrane. This arrangement permits osmosis to go on readily.

Self-test, p. 392. 1. From the nose to the throat (or pharynx), through the larynx (or voice box), thence in turn through trachea (or windpipe) and bronchial tubes (or bronchi) to alveoli. The path is retraced on the return journey (see the figure on page 389). 2. Change dry to moist. 3. Dust. 4. Oxygen; carbon dioxide. 5. Change pulled to pushed. 6. R.

Self-test on Biological Principles, p. 393. The evidence is that the more complex organisms have a number of special respiratory structures, each having its own part in the division of labor. The simple organisms have no special respiratory structures and no division of labor.

Self-test on Organization of Facts, p. 393. Protozoa, sponges, and coelenterates: no special structures; osmosis through the cell membrane. Earthworm: no special structures; osmosis through the skin. Starfish: special tissues on the body surface. Clam and oyster: gills, located along the sides of the body. Fish: gills on the sides of the head. Insects: air tubes. Snail (certain species): primitive lung. Frog and higher vertebrates: lungs.

Problems, p. 393. 1. A frog or a toad depends on its moist skin for the absorption of some of the oxygen it needs. All Amphibia are similar to the frog in this respect and therefore are usually found in moist places where the skin will not dry out rapidly. 2. They are better able to expand into all available space than would be possible if they had cartilaginous walls. 3. The burrows fill with water, which at first contains dissolved oxygen ample to supply the earthworm. When the oxygen is all used, the worm must come to the surface or it will die. 4. Resemblances: Exchange of gases is carried on through a thin moist membrane. Differences: In the amoeba the exchange goes on in the entire body surface. In man the first exchange occurs in the lungs, where oxygen is taken into the blood and carbon dioxide is given off; later the blood gives oxygen to the cells and takes carbon dioxide from them. This process is cell respiration. 5. One breathes more rapidly because there is less air, and therefore less oxygen. One probably breathes with greater difficulty because the air pressure is less.

Exercises on Scientific Method, p. 393. 1. The current of water which passes over the gills of the crayfish always flows in a forward direction. This natural flow would be aided if the crayfish faced away from the direction of flow in a stream. The fish takes in water through the mouth and forces it backward over the gills. Thus by facing upstream the fish uses the current as an aid to respiration. 2. Arrange apparatus similar to that shown in the figure on page 382. Use seeds in place of the growing seedling.

Chapter XIX

Figure, p. 395. The diagram shows that food and oxygen enter the body by different paths. In the cells the paths join. Wastes which result from cell activities go out by still another path. Before metabolism occurs, food-getting and ingestion must have taken place. The processes included in metabolism are digestion, absorption, circulation, assimilation, and oxidation of food. Some authorities restrict the meaning of metabolism to the building of protoplasm and the release of energy within the cell, or, in other words, to assimilation and oxidation. This restricted use is becoming less common than formerly.

Self-test, p. 395. 1. Change usually to always. 2. R. 3. Carbon dioxide, water, urea. 4. Lungs; intestines.

Figure, p. 396. The action of the contractile vacuoles is explained on page 396.

Figure, p. 397. The earthworm has definite groups of cells (nephridia) which have the special function of excreting wastes.

Self-test, p. 398. 1. Solid. 2. Change rudimentary to no. 3. Change one pair to many pairs. 4. Exoskeletons. 5. Mollusks. 6. Transpose bladder and kidneys.

Self-test on Organization of Facts, p. 398. Osmosis, etc.: Amoeba, phylum Protozoa. No organs, etc.: Paramecium, phylum Protozoa. Division of labor, etc.: earthworm, phylum Annelida. One pair of complex tubes: mussel, phylum Mollusca. More highly specialized organs, etc.: frog, man, phylum Chordata.

Figure, p. 399. Liver, lungs, sweat glands.

Experiment 54, p. 399. The larger blood vessels and the ureter will show as in the figure on page 399. The section through the kidney will show the cortex (a definite, solid-appearing outer layer) and the medulla (the inner, more folded region). In the center of the kidney there is the cavity into which the tubules empty the urine secreted by the kidney. The ureter leads from this cavity to the bladder.

Figure, p. 400. Protects the body; contains nerve endings of touch; regulates loss of heat.

Self-test, p. 401. 1. Urea. 2. Ammonium. 3. Urea. 4. R. 5. Sweat glands. 6. Change eliminate wastes to regulate temperature. 7. Five points are given on pages 400 and 401.

Self-test on Organization of Facts, p. 401. Leaves of plants give off water and carbon dioxide; solid wastes composing part of the leaves are shed. Roots of plants eliminate organic wastes. Contractile vacuoles of Protozoa excrete water, carbon dioxide, solid wastes. Nephridia of earthworm excrete water and urea. Skin of earthworm gives off carbon dioxide. Malpighian tubes of insects excrete water and urea. Tracheae of insect give off carbon dioxide. Gills of fish or crayfish give off carbon dioxide. Lungs of higher animals give off carbon dioxide and water. Kidneys and bladder eliminate water and urea. Liver changes ammonium compounds to urea. Sweat glands excrete water, urea, and salts.

Self-test on Biological Principles, p. 401. Simple animals, like the Protozoa, have no special organs for excreting wastes. A more complex organism, as the earthworm, has numerous excretory tubules. Higher animals have several structures serving for excretion: kidneys, liver, lungs, bladder, and sweat glands.

Problems, p. 401. 1. Fanning hastens evaporation of moisture by removing the vapor-laden layers of air which were in contact with the skin, thus allowing fresh air to take up moisture from the skin. 2. The water assists in dissolving solid wastes and in reducing their concentration, thus making it easier for the kidneys to eliminate them. 3. The blood leaving the kidneys contains very little urea, and less water than when it came to them. 4. Work necessitates more rapid oxidation of food and consequent production of heat. Excess heat is eliminated largely through evaporation of sweat from the skin. A man who has no sweat glands would get too hot to work.

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Figure, p. 403. Pituitary gland.

Figure, top of page 404. The lymph, with the hormones which have been secreted into it, is collected by the lymphatics. The largest of these lymphatics (the thoracic duct) empties into one of the large veins which return blood to the heart (see figure facing page 372). From this point, one has only to follow the circulation of the blood to trace the path by which the hormones reach any part of the body.

Figure, bottom of page 404. A simple gland. It consists of a coiled tube which is not branched as is a complex gland.

Figure, p. 405. In order to bring to the glands an abundance of all the substances out of which the glands make their secretions.

Figure, p. 406. By feeding the child thyroid extract.

Figure, p. 407. Adrenal glands.

Self-test, p. 409. 1. Change all to many. 2. Transpose endocrine and duct. 3. (1). 4. 1, i; 2, f; 3, c; 4, b; 5, h; 6, g.

Problem, p. 410. Among the glands discussed should be the liver, pancreas, gastric glands, mucous glands, salivary glands, intestinal glands, sweat glands, sebaceous glands (p. 400), mammary glands, poison glands (pp. 217, 311), glands which secrete shells, perfume, etc. (p. 402), thyroid glands, parathyroid glands, pineal glands, pituitary glands, adrenal glands, and reproductive glands.

Exercise in Scientific Method and Scientific Attitudes, p. 410. Elements of scientific method 2, 3, 6, 9; scientific attitudes 1, 6, 9.

UNIT VI

Unit Objectives: (1) To teach how living things react to various factors and conditions in the environment. (2) To make clear how living things learn, and what learning means. (3) To afford further illustrations to teach that "complexity of structure goes hand in hand with division of labor." (4) To develop knowledge and proper care of certain human sense organs.

Chapter XXI

Figure, p. 415. Irritability on the part of the bears is shown by their awareness of the presence of an enemy, and response by climbing the tree to escape. The dog shows irritability and response by its jumping and barking.

Experiment 55, p. 415. The roots do not continue to grow in the direction in which they started, but will grow downward. The stems grow upward. Scientific Method: If only one seed had been used, the observer might have concluded that it was growing in some unusual manner. He could not have concluded from a single specimen that roots characteristically act in that way. The different kinds of seeds served as controls in showing that the behavior observed was not due to the peculiar reactions of one particular kind of seed.

Figure, p. 416. The statement "Different sorts of living things react to the same stimulus in very different ways," found at the top of page 415.

Figure, p. 417. Scientific attitude 10 especially.

Experiment 56, p. 418. The animals named will probably show negative tropism toward light. The intensity of the light has much to do with the reactions of the animals.

Self-test, p. 418. 1. (4). 2. Change leaves to roots. 3. Change difficult to impossible. 4. Change few to no. 5. Change seldom to usually.

Figure, p. 419. See page 32.

Figure, p. 420. The impulse travels over the nerve net to all parts of the body and stimulates the muscle cells to contract. The name net refers to the fact that the nerves are joined in a web, or are woven together.

Figure, p. 421. The nervous tissue is centralized in a ventral nerve cord and a brain. There are not only certain nerves for receiving impressions but also other nerves which carry responses to the muscle cells.

Experiment 57, p. 421. When placed on moist sand the earthworm begins to burrow beneath the sand. Probably the contact and the moisture in the sand cause it to react as it does. When one taps on the box, the worm moves, thus showing that it is sensitive to the vibrations caused by the tapping. The head end of the worm is most sensitive to touch.

Self-test, p. 421. 1. Change simple to no. 2. Change less to more. 3. Change complex to simple. 4. Neurons. 5. R. 6. (2). 7. Instinct.

Figure, p. 422. The wasp does not learn to make its nest, but does so by instinct. No wasp is taught by its parents.

Figure, p. 423. The ichneumon fly's behavior was instinctive. Although the actions seemed planned and carefully executed, they were purely mechanical. Such instinctive actions are inherited.

Figure, p. 424. The natural instinct to build in a tall tree was modified when the bird found what seemed a more suitable site.

Self-test, p. 425. 1. Change legs to heads. 2. R. 3. Change a reflex to an instinct. 4. Change tropism to reflex. 5. Change reflex to tropism.

Left Figure, p. 426. Olfactory nerve carries stimuli from the nerve endings in the nose to the olfactory lobes, where the sensation is interpreted as smell. Cerebrum probably controls voluntary movement. Optic lobes are the centers of vision. Cerebellum controls co-ordination of movement. Medulla controls involuntary actions, such as heart-beat. Spinal cord is a pathway for nerve fibers to and from the brain.

Right Figure, p. 426. Larger than the cerebrum of any of the animal brains shown, because the figures show that in general the size of the cerebrum is greater in the animals that are higher in the scale of life.

Figure, p. 427. See page 427.

Figure, p. 428. The nerve endings receive the heat stimulus, which is carried by the sensory nerve to the spinal cord. Here the impulse passes from the dendrites of the sensory cell to the dendrites of a motor cell, and along the motor neuron to the muscle cells, causing them to contract and pull the hand away. Since this reflex action is carried out entirely by the spinal cord, the hand is jerked away before nerve endings sensitive to pain have carried the impulse to the brain, causing the feeling of burning.

Figure, p. 429. Such activities as digestion, excretion, circulation, and the activities of glands.

Self-test, p. 429. 1. Change most to all. 2. Change less to more. 3. Brain, spinal cord, and nerves. 4. Change medulla to cerebrum. 5. R. 6. Change cerebrum to cerebellum. 7. Change cerebrum to spinal cord. 8. Change increased to decreased; change cerebellum to spinal cord. 9. R., or change small benefit to considerable harm.

Self-test on Biological Principles, p. 430. 1. All the unlearned responses are inherited and automatic. Reflexes are more complex than tropisms, and instincts are more complex than reflexes. But it is difficult in many cases to decide exactly where the dividing line is. 2. In the hydra, with a nerve net, there is little division of labor in the nervous system. But in a complex animal, like the frog, there are several organs making up the nervous system, each with special functions. 3. "Tropisms, reflexes, and instincts are alike in being inherited and unlearned." "Higher types of response are in general more easily modified than lower types."

Problems, p. 430. 1. Hydrotropism, which is the tendency of roots to grow toward water, will cause the roots to grow to the lower layers of moist soil in the pot. 2. Phototropism, which is the response to light, aids in photosynthesis, because the plant tends to grow toward the source of light and therefore has better chances of avoiding shading by other plants or other objects. The tendency to respond to water (hydrotropism) enables the roots to secure the water supplies needed. The tendency of roots to grow downward into the soil (geotropism) enables the plant to establish strong supporting roots. 3. As an instinctive action. 4. The medulla is liable to be injured. Since this part of the brain controls such necessary activities as breathing and heartbeat, injury to it is more liable to result fatally than an injury suffered by other parts of the brain.

Chapter XXII

Figure, p. 432. Yes, the natural instincts of fear and antagonism are being modified as these animals live together.

Figure, p. 433. Dogs which are trained to guide their blind owners safely enable such persons to lead more nearly normal lives than otherwise would be possible, and often enable them to engage in gainful occupations.

Figure, p. 434. Horses have more highly developed brains than have fleas and can therefore react, learn, and remember more.

Figure, p. 435. Yes, the turtle does not learn this, but goes through all the actions concerned with making the nest and depositing the eggs in exactly the same way as every other turtle of its kind.

Figure, p. 436. First modify the natural instincts of fear and fighting by teaching the animals while they are young to be together, especially at feeding time, when a feeling of pleasure and satisfaction may be uppermost. First the dog must be taught to hold the stick; to hold it while one of the other animals occupies its place -- for example, while the squirrel sits on his head or the rooster perches on the stick. Then one by one the other animals are added until over a considerable period of time the group is completed. Reward the animals with food when they do as you wish, and withhold the food until they have done so. Kindness, firmness, and extraordinary patience must be maintained throughout the training.

Figure, p. 437. A chick placed in C felt annoyance at being separated from his companions. By trial and error he found the way into A. Here he experienced pleasure at finding food and companionship.

Figure, p. 439. Once the elephant has formed a habit, the path of his reactions is fixed. He does not think of new ways to do the work or plan ahead to other activities he would like to carry on.

Self-test, p. 440. 1. Change unlearned to learned. 2. Change none to all; change is to are. 3. Change two to all. 4. Change little to nothing. 5. Habit. 6. Change little to no. 7. Change less to more. 8. Change some to no.

Figure, p. 441. The convolutions increase the area over which gray matter is distributed, thereby providing great increase in the amount of gray matter.

Figure, p. 442. (1) First, if one is to learn to play well, there must be the sincere desire to learn to play or to improve one's playing. (2) Secure instruction in the proper way to place the feet and the hands and to make the correct swing. (3) Practice carefully, thinking of these instructions as you move. (4) Permit no bad habits to enter into your playing. (5) Practice frequently until the correct habits are established, always holding yourself to the correct standards of good performance.

Figure, p. 444. There will be great variety in the suggestions made by pupils. An interesting group project is to choose some habit which the class would like to form, as always leaving the laboratory neat and clean or always using the approved method (whatever that may be in their particular school) before beginning to speak in class. Then have members of the class keep records for a week or longer to determine how long it takes the class to learn that habit.

Figure, p. 446. That old people can accomplish important work.

Figure, p. 448. The mother sheep furnishes milk for the lamb; she leads it away from the photographer who is taking the picture.

Self-test, p. 448. 1. Change the elephant to man. 2. Cerebrum. 3. Change few to no. 4. Change higher to lower. 5. Change difficult to impossible. 6. R. 7. Change few to most; change though to if. 8. Change poor to good. 9. Change less to more. 10. (4).

Self-test on Biological Principles, p. 449. 1. The crawling reflex of an earthworm aids the animal in escaping enemies or in reaching its food. The instinctive actions of a young bird in pecking at food aid it directly in securing food energy. The action of the amoeba in avoiding a beam of light was an aid in conserving energy, in that such action may have prevented the amoeba from drying out or becoming too hot and so being killed. (Many similar examples will probably be given.) 2. In general, it is true that "the higher in the scale of life an animal is, the more complex a maze it can learn." There are exceptions, however; for the ant, which is of a lower phylum than fish and frogs, showed ability to learn a more complex maze.

Problems, p. 449. 1. The annoyance of being caught and lifted from the water came to be connected with eating the worm and served to aid the carp in learning not to eat a worm which was on a hook. Also, the pleasure derived from eating a worm which was not on a hook aided the carp to detect and eat only such worms. 2. A baby has to learn to walk. At birth its nerve paths necessary to control walking movements are not completed. 3. Man's erect posture permits him to use his hands and arms freely and to have a less restricted vision than have four-footed animals of about the same size. 4. (1) Learning results from experience. (2) Learning consists in modifying responses. (3) Learning begins with inherited reactions. (4) Learning involves choice of response. (5) Learning depends largely upon pleasure and annoyance. (6) Simple learning is a trial-and-error process. (7) Learning frequently involves habit formation. The meadow larks had inherited the necessary nerve patterns to make pecking possible, but they had to have experience in learning how to eat a worm. They responded to the sight of a worm by instinctive peckings; annoyance when not successful in securing a worm, or pleasure when successful, helped to modify this reaction until through frequent trial-and-error movements success became more frequent. Finally an effective habit of picking up worms became fixed. 5. The rules are the same as for the formation of any habits. First, there must be the desire to learn to drive, or at least there must be no contrary desires. Begin by having the proper method of shifting gears, steering, etc. explained. Then perform the movements indicated, thinking as you do them. Do each movement over and over again in the right way. Eliminate wrong movements and unnecessary ones. Finally the nerve paths which aid in performing the actions necessary to driving are so well established that one no longer has to think about each movement. 6. Man has a highly complex brain, with almost infinite numbers of possible nerve associations which he can learn to make. Dogs and other mammals are born with most of these nerve associations already established. They therefore reach much earlier in life the limit of the numbers of things they can learn. 7. He must first sincerely desire to form the habit of controlling his temper. He can consciously try to avoid losing his temper, perhaps using such an aid as counting to ten before speaking when he feels himself becoming angry. He must permit no failures if he really hopes to overcome this habit; or, if a failure occurs, he must do all in his power to remove its effects and to avoid a repetition of it. 8. Cats and monkeys can learn only by a trial-and-error process. They cannot reason from observation or analyze a movement and then use it in their own actions. 9. One may remember an event, as a thunderstorm or a picnic or where one went yesterday, even though no learning is involved, because the happening was very familiar. On the other hand, learning necessarily involves remembering because if an experience is not remembered, it cannot be used as a basis for forming a fixed reaction. A rat could not learn a maze if it did not remember the correct turns; a person could not learn to type if he did not remember the correct keys to strike. 10. Yes, even the simplest animal must remember the actions it has performed if it is to learn to modify its behavior.

Exercises on Scientific Method, p. 450. 1. If the animals react in ways which have been observed in other animals or if they react in the same way several times, one might accept this evidence as scientific. But one is not justified in concluding that another animal of the same kind would necessarily react in the same way to the same situation. Also, one cannot be certain in stating what an animal thinks, because there is no conclusive evidence that animals lower than man do think. Furthermore, their mental processes must differ considerably from those of man, and one cannot be sure he is right in judging merely on the basis of human reactions what animals like or dislike. 2. The only conclusion justified from the single result of the experiment given is that the particular horse that was used in this experiment learned less readily than any of the other animals used in this same experiment. But one would not be justified in concluding from this one experiment that horses in general are "stupider" than any of the other kinds of animals used -- even man. (See scientific attitude 9.)

Exercise on Scientific Attitudes, p. 450. A phrenologist's claims are not scientific. The bony structure of the skull in no way indicates what or where the various brain centers are. (Scientific attitudes 3 and 8 chiefly.)

Chapter XXIII

Experiment 58, p. 451. The pupil should find distinct spots, irregularly distributed, which are especially sensitive to pain, heat, and cold. Perhaps nerve endings of pressure will be harder to locate. A nerve ending sensitive to heat will respond by giving a sensation of heat, even when touched with a cold object.

Figure, p. 452. The drooping and folding of the leaves may keep them from being broken off or may serve to frighten some enemies. The principle here may be stated thus: "If an organism is able to make a reaction which is favorable to its survival, that organism is more likely to continue to live and to reproduce others capable of making the same reaction than are other organisms of the same kind which are incapable of the reaction."

Experiment 59, p. 452. On the back of the hand the nerve endings of pressure are usually about $\frac{1}{8}$ to $\frac{1}{4}$ inch apart. On the finger tips or the tongue they are so close together that one can distinguish two pin points as distinct, even when they are almost together. On the shoulder or the back one can sometimes move the pins two inches apart before they can be distinguished as separate.

Left Figure, p. 453. The vorticella has been touched or has come in contact with food and has ingested it. Either stimulus would have been sufficient to cause the stalk and the bell to contract.

Right Figure, p. 453. It may be able to detect sources of food more readily than if it were necessary to uncoil the tongue every time it sampled anything. Also, when flying, the coiled tongue can be more easily carried and with less danger of injury to it.

Figure, p. 454. Sight. One observing an eagle soaring high in the air and then darting downward would seem justified in concluding that it had seen food. Birds of prey have "telescopic vision."

Figure, p. 455. By being in pits which open into grooves on the tongue; by being surrounded by protective cells. They are less likely to be injured by hot foods or other irritating substances.

Figure, p. 456. Simple animals do not have the complex structures characteristic of higher forms.

Self-test, p. 456. 1. Sight, hearing, smell, taste, pressure, heat, cold, pain, equilibrium, and kinesthetic. 2. Change sight to touch. 3. Eyes, ears, taste buds, sense organs of smell. 4. Change touch to smell. 5. Change arthropods to mammals. 6. Smell. 7. Change entirely to largely.

Figure, p. 457. Most spiders have eight eyes, but the arrangement varies in different species.

Figure, p. 458. Similarities: The eyes are found on the head in both animals. Both kinds of eyes are special organs sensitive to light. Differences: The octopus has a lens-type eye, very similar to that of man: all parts work together in seeing. An insect has a compound eye, composed of many facets: each small part works independently. The eye of the octopus is probably more capable of seeing its surroundings accurately; that of the insect is thought to be useful chiefly in detecting movement and difference in light and shadow. The eyes of an insect are usually larger in comparison with the size of the head.

Figure, p. 459. The lens serves to focus light rays on the retina. In the retina are the nerve endings of the optic nerve. All the sensations received by these endings are transmitted to the brain by way of the optic nerve. The suspensory ligament fastens the lens in place; the ciliary body serves to regulate the thickness of the lens. The iris regulates the amount of light admitted to the eye; the pupil is the opening in the iris through which the light passes. The cornea serves both as a transparent window through which light passes and as a firm covering to protect the front of the eye. The aqueous and vitreous humors serve largely to keep the eyeball in shape. The chorioid coat is the middle layer of the eyeball in which blood vessels are found. The sclera is the tough outer covering, which is continuous with the cornea in front.

Self-test, p. 459. 1. (4). 2. Lens type, compound eye, simple eye, eyespot, nerve endings sensitive to light. 3. Two. 4. Change difficult to impossible.

Figure, top of page 460. To the ear-drum, or tympanum.

Figure, bottom of page 460. This explanation is given on the same page, to be used in connection with the labels on the figure.

Figure, p. 462. It is contradictory; there is no evidence that the rattlesnakes could hear. Scientific attitudes: chiefly 3, 7, 8, 9, 10, 13.

Self-test, p. 463. 1. Change possible to impossible: change many to any. 2. (4). 3. R. (Hearing, as we ordinarily think of it, is impossible unless the bones of the middle ear vibrate. But deaf persons may sometimes hear through the vibrations carried to the auditory nerves by the bones of the skull.) 4. Balance; hearing. 5. Change somewhat less to much more. 6. Rapid; slow. 7. R. (We should need to depend upon the kinesthetic sense and the sense of sight.) 8. F. 9. R.

Figure, p. 464. The alert attitude of the animals indicates that they are keenly sensitive to sights, smells, and sounds which are different and which may indicate the presence of enemies.

Self-test on Biological Principles, p. 464. "...In general the higher the order of bird, the less keen is its sense of smell." (Part of the last sentence in the second paragraph.)

Problems, p. 464. 1. The bulging eyes of the frog enable it to see behind it, even though the head is not movable; they also enable the frog to rest in the water with only the eyes and nose protruding. 2. The transparent nictitating membrane protects the eye-ball and permits the frog to see under water.

Exercises on Scientific Method, p. 465. 1. One can infer that turkey buzzards have very poor sense of smell. The experiment was repeated as a check experiment or a control to make sure that the results observed in the first case were not a matter of chance. As further check experiments, one might cover the meat with boards or leaves or anything which would hide it without preventing odors from escaping; also, one might try the same experiment in other localities with different turkey buzzards. One could not conclude that all carrion-eating birds would react in the same way these turkey buzzards reacted; this experiment could not demonstrate any facts about the sense of smell in other species of birds. 2. Dry the surface of the tongue as well as possible with absorbent cotton or soft cloth. Then dissolve the various substances in water and place a drop of each solution in turn on the various parts of the tongue as specified. It will be necessary to rinse the mouth thoroughly and to dry the tongue, after experimenting with each substance, before experimenting with the next. 3. The spider may not have a sufficiently keen sense of sight to detect a grasshopper at a distance of more than eight inches, but can see it clearly at a distance of four inches. The spider may recognize its prey at a distance, but may wait until it is close before attacking. This spider might have reacted as it did because it was very hungry or because it was not hungry. It must be kept in mind that this particular spider may have reacted to the prey in an altogether different manner from that of other spiders of the same species under the same circumstances. One cannot be certain that his explanation is entirely right, because he has no way of seeing things from the spider's point of view. 4. It is difficult to study the vision of lower animals because their eyes are so different from those of man that he cannot be sure that he interprets correctly the manner in which light affects them. Then, too, lower animals react to stimuli in ways so different from the ways in which man reacts that we cannot say for certain when they do or do not see; they may be aware of their surroundings and yet have no impulse to react to them as man would. 5. The evidence supplied by the story does not indicate that any birds except young chickens hear any sounds except the two described. The only birds observed here were chickens, and the only sounds to which they were observed to react were two calls of the mother hen. The responses of the chicks were instinctive and unlearned reactions. Any young chickens will react in the same manner, the first time they hear such sounds, without training of any sort. 6. Nos. 2, 3, 5, 6, 7. 7. There will doubtless be wide variations in accuracy of hearing among the individuals of the class. The cat or the dog will probably have keener hearing than most of the pupils. The power of suggestion may cause the pupils to think they hear when they do not; also, some may say they hear when they do not, because they believe they are expected to hear. A check experiment is necessary in which the pupils are asked to tell, when the fork is not vibrating, whether or not they hear the sound. Such a check experiment will indicate whether the pupil is accurately reporting when he hears and when he does not. 8. If the apple, onion, and potato are all finely scraped, so that one cannot distinguish them by the texture, it is almost impossible to identify them. It is really the difference in smell which chiefly enables us to enjoy different foods.

UNIT VII

Unit Objectives: (1) To present useful facts about bacteria and other microscopic organisms. (2) To give an understanding of how man opposes his enemies which cause disease. (3) To teach necessary and practical knowledge about physiology and hygiene.

Chapter XXIV

Figure, p. 470. (1) People with infected feet may leave spores on shower-bath floors or around swimming pools; combs, towels, and clothing may become infected. (2) Provide antiseptic foot baths in public showers and pools. Be sure the barber or the hairdresser uses sterile combs and towels. (3) Thorough cleansing with antiseptic soap, washing with alcohol or other sterilizing substance, application of germicidal and healing salve, use of clean clothing. Consult physician for special advice.

Self-test, p. 472. 1. Enemy. 2. Change saprophytes to parasites. 3. (1).

Figure, p. 473. Body louse: typhus fever, trench fever. Flea: bubonic plague. Housefly: tuberculosis and typhoid fever. Cockroach: typhoid, tuberculosis, and parasitic worms. Cattle tick: Texas cattle fever. Malarial mosquito: malarial parasite.

Figure, p. 474. (1) By using all possible precautions to prevent rats not only from landing in this country from ships but from getting on the ships in foreign ports; (2) by fumigating the ships to kill the rats and their fleas.

Figure, p. 476. Those that are eaten without having the outside skins removed, as apples, grapes, plums, and cherries.

Figure, p. 477. The laboratory can move quickly to the place where it is needed; the fact that it moves about the country gives it an educative value to the people who see it and who might never see or know about the city laboratory.

Self-test, p. 478. 1. Change all to some in both cases. 2. R. 3. Change noncommunicable to communicable. 4. R. 5. See pages 474-475. 6. (3). 7. (2) and (7) (because these are not communicable diseases). 8. See page 477. 9. Change many to few.

Figure, p. 479. Have a class report upon your local-school provisions.

Figure, p. 480. A, coccus types; B, bacillus types; C, spirillum types.

Self-test, p. 481. 1. See pages 479-481. 2. Change usually to always. 3. (3). 4. (6).

Figure, p. 483. (1) Increasing scientific knowledge of the nature of the diseases, with a consequent improvement in methods of prevention and treatment; (2) more sanitary living conditions; (3) better quarantine regulations and better enforcement of them; (4) growing intelligence concerning these diseases on the part of people in general and a consequently better co-operation of the average citizen with health departments.

Figure, p. 485. Sunlight kills bacteria. It also promotes health and helps people to recover from illness. Plenty of fresh air is important both to prevent the spread of disease germs from person to person and to supply a healthful environment for those who are ill or are recovering from illness.

Figure, p. 487. Fresh air, recreation, and especially sunshine are aids to health. These provide better supply of oxygen, improve circulation, and help in various ways in opposing disease.

Self-test, p. 488. 1. See page 482. 2. See pages 483-484. 3. (7) (All the rest are either germicidal or otherwise offer protection against germs.) 4. See page 486. 5. See "Factors affecting immunity," p. 486). 6. Antitoxin.

Problems, p. 488. 1. Darkness, moisture, warmth, and abundant food. 2. There is not only a greater chance that in a crowded room one will be brought in close contact with a greater number of communicable diseases, but, if the ventilation is poor, there is less chance for the disease germs to be dispersed. 3. The oysters have become polluted with typhoid bacteria by being in water into which sewage has drained. 4. Food: (1) by protecting it from flies, other insects, and other contaminating agents, such as dirty hands (cellophane offers such protection); (2) by prohibiting people who are suffering from communicable diseases from handling food; (3) by enforcing rigorous inspection of all sources and of handling of foods; (4) by effective refrigeration (refrigeration does not kill bacteria, but it decreases their activities and the rates of reproduction for many harmful species). Drinking water: (1) by safeguarding it from contamination; (2) by having sufficiently frequent tests of the water. 5. Such diseases not only weaken the victim but also frequently leave serious "after effects," such as impaired hearing or eyesight.

Exercises on Scientific Method, p. 488. 1. Pasteur located problems, learned what was already known about these problems, made hypotheses from facts, evaluated data and procedures, evaluated conclusions, planned and made new observations and experiments, made inferences from his work, used controls, and isolated experimental factors. 2. City dwellers are more frequently exposed to scarlet fever and consequently are likely to produce more antibodies. 3. In step 1, Koch used normal tissues as a control; the normal animals which are not inoculated (in step 3) serve as controls, since their condition is compared with that of the inoculated animals.

Figure, p. 489. Nos. 2, 3, 5, 7.

Exercise on Scientific Attitudes, p. 490. 1. Especially 2, 3, 5, 6, 7, 8, 9. 2. Especially 5.

Figure, p. 491. By inquiry at libraries, interested pupils may find other engaging stories of the heroism of science.

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Figure, p. 493. Modern methods of disease prevention are based upon scientific research, while the medicine man's so-called cures are largely based upon superstitious beliefs and practices.

Figure, p. 494. Especially 10 and 13.

Figure, p. 495. In the first period, deaths decreased from 900 in 1923 to 212 in 1932; in the second period, they decreased from 212 in 1932 to 57 in 1937.

Figure, p. 496. Especially 4, and probably 3 and 13.

Self-test, p. 498. 1. (2). 2. (5). 3. Schick. 4. Smallpox. 5. (2).

Figure, p. 499. Microscope, stethoscope, and X ray.

Figure, p. 500. In 1900 there were 200 deaths per 100,000 population (as shown by the 20 crosses); in 1937 there were about 50 deaths per 100,000.

Figure, p. 502. Rest, sunshine, fresh air.

Figure, p. 503. It enables the doctor often to detect incipient diseases and to check or stop them before they become serious.

Self-test, p. 504. 1. R. 2. R. 3. Change some to no. 4. See page 500. 5. Change an adult to a child.

Figure, p. 505. The labels on the diagrams, and the text discussion on pages 504-506, provide adequate explanation.

Figure, p. 507. The eggs of the malarial and the yellow-fever mosquitoes are separate; the malarial-mosquito larva lies parallel to the water surface, while the adult "stands on its head"; the third pair of legs of the yellow-fever mosquito stand most nearly parallel to the body. Means of exterminating mosquitoes include (1) draining breeding places; (2) screening cisterns and other standing-water containers; (3) using oil on swamps; (4) introducing fish to eat the larvae. The oil forms a film on the water, through which the larva cannot push its breathing opening. (It is air-breathing and cannot take oxygen from the water.)

Self-test, p. 508. 1. Yellow fever; (2). 2. Change few to no. 3. Malarial. 4. Malaria; change white to red.

Social Implications, p. 508. Spitting is likely to spread diseases; for that reason it is prohibited by law in many public conveyances and public buildings. If cows are tested for tuberculosis, the number of cases of that disease which arise from milk can be reduced. Compulsory use of the Schick test and of toxin-antitoxin treatment would soon enable us to eradicate diphtheria.

Problems, p. 508. 1. The horse is able to withstand the disease better and to produce much greater quantities of antitoxin. 2. The proper treatment can be begun before the disease becomes serious; also, the patient can be isolated, thus preventing his infecting others.

Exercises on Scientific Method, p. 508. 1. When in the forest in a tsetse-fly region, wear gloves to cover hands and wrists, and wear mosquito netting around the head; clear all underbrush from around dwellings; keep dwellings well screened. 2. There are no persons who have the disease from whom the mosquitoes can get the parasite.

Exercise on Scientific Method and Scientific Attitudes, p. 508. Scientific attitudes 3, 6, 7, 8, 9, 11. Lazear, Dean, and Carroll were each a control on the other two, since all were subjected to the same conditions in order to make sure that contracting or resisting the disease was not a matter of chance or of personal differences. Other people who were present, but who were known to have escaped being bitten by suspected mosquitoes, likewise served as controls. Kissinger and Moran were each controls upon themselves because each was first carefully protected from being bitten by mosquitoes and later allowed to be bitten by suspected mosquitoes. Since these two men were subjected to the two conditions, being bitten and not being bitten by suspected mosquitoes, they served as well for controls as would another group which were either kept from being bitten or were allowed to be bitten. While Kissinger and Moran were subjected to the opposite condition, they needed to be isolated long enough to make it certain that they had not contracted the disease previous to the experiment. Before the doctors could be certain that yellow fever was not passed directly from a sick person to another person or that it was not contracted from clothing and bedding that had been used by patients, more experiments had to be made. In these, persons who were well wore the clothing of yellow-fever victims and slept in their beds. These experiments needed to be controlled carefully enough so that it was certain that people could contract the disease in no other way than by the bites of infected Aedes mosquitoes. Then, also, every one of these experiments would need to result in no cases of yellow fever before certainty could be announced. These experiments could not prove that the mosquito was the only possible carrier, because no other possible carrier was studied. The abbreviated story here given does not indicate that Reed followed the four steps of Koch. Step 2 (isolating the suspected organism in pure culture) has never been achieved for yellow fever.

Chapter XXVI

Figure, p. 511. One gets active exercise in the fresh air and sunshine. Also, it is a pleasurable activity, and as such promotes mental health.

Figure, p. 512. Only a good physician is able to determine the nature of one's symptoms. (Time should be taken in class to read and discuss the newspaper headings in the figure.)

Figure, p. 513. The control offers a means of comparison. Without it one could not know whether the "wheat and spinach reactions" or the corn and beef ones were the normal reactions.

Figure, p. 514. They may lead to the habit of drinking excessively.

Self-test, p. 515. *1*. Change *seldom* to *often*; change *usually* to *rarely*. *2*. Change *patent medicines* to *diet* (or *physician's advice*.) *3*. Change *usually* to *rarely*. *4*. *R*. *5*. Change *helpful* to *harmful*.

Figure, p. 516. The six-year molars and second molars are shown partly developed in the back of the jaws shown in side views.

Figure, p. 517. Brushing the gums serves to massage them and to promote a healthy circulation of blood through them, thus keeping them firm and healthy.

Figure, p. 518. Chewing is certain to be more effective, and hence digestion will be facilitated; also, the satisfaction and confidence gained by the knowledge that one has attractive teeth are important.

Self-test, p. 518. *1*. Twenty. *2*. Thirty-two. *3*. Change *extracted* to *kept* or *retained*, and change *soon* to *long*. *4*. (1), (3), (5), (6), (7).

Figure, p. 520. When air is warmed it expands and becomes less dense; that is, its weight per cubic foot becomes less. It is therefore pushed to the ceiling and out of the upper opening by the colder, denser air.

Self-test, p. 520. *1*. Change *mouth* to *nose*. *2*. Change *desirable* to *undesirable*. *3*. *R*. *4*. To circulate the air and thus to remove excess water vapor. *5*. Change *easier* to *harder*.

Figure, p. 521. (1) Helps circulation and elimination; (2) stimulate lymphatic circulation; (3) give recreation; (4) expose the body to sunshine; (5) promote mental health.

Figure, p. 522. In assuming correct posture one is using the muscles which need to be developed in order to make good posture possible; also, one is establishing a habit of good posture. The first pose illustrates correct standing posture.

Figure, p. 525. The cooling effect of breezes from the water tends to make one remain in the sun longer than he otherwise would. Heliophobes are persons who do not tan but instead continue to sunburn.

Self-test, p. 526. *1*. Change *exercise* to *rest*. *2*. Change *less* to *more*. *3*. Change *slightly inward* to *straight ahead*. *4*. Change *more* to *less*. *5*. Consult one's family physician or a specialist. *6*. American Medical Association.

Figure, p. 527. Below the cut. The pressure in the arteries is greater than that in the veins; hence the severing of an artery causes more rapid loss of blood than the severing of a vein.

Self-test, p. 528. 1. Transpose head and feet. 2. Change an hour to ten (or fifteen) minutes. 3. Drowning.

Figure, p. 530. Fifty-seven or fifty-eight years.

Figure, p. 533. No. 5.

Figure, p. 534. They may make a person think he is getting better, and so make him put off seeing a doctor until it is too late; they tempt people to try to diagnose their own ills and to try various cures on the basis of their diagnoses.

Self-test, p. 535. 1. Change less to more in each case. 2. R. (though if they are used intentionally by a consumer in place of olive oil, they are substitutes). 3. R. 4. R.

Figure, p. 536. Hobbies give a person interesting individual problems to occupy his mind during leisure hours. He learns to plan for himself and to carry an engaging activity to completion to his own satisfaction. He may gain commendable personal pride through an achievement of his own selection.

Figure, p. 537. Pleasurable activity in pleasant surroundings; the ability to relax and have fun.

Self-test, p. 538. 1. Change possible to impossible. 2. R.

Problems, p. 539. 1. Substitutes: corn oil or cottonseed oil for olive oil; sirup or molasses for sugar; cheese for meat; nuts for meat. Adulterants: formaldehyde added to milk to keep it from spoiling; grated turnip in horseradish; shredded carrot instead of shredded coconut; unwholesome coloring, alum, or saccharin in pickles. 2. The proprietor was complying with the letter of the law in declaring the adulterant he used, but not the spirit of the law, since he was trying to represent the preservative as desirable. 3. One must first secure a clear idea of what constitutes good posture. He must then experiment or have instruction until he knows when he has assumed good posture. He must then assume good posture regularly and must make an effort to avoid bad posture. Finally, good posture may become automatic. 4. The spine is unnaturally curved; the lungs and other organs are compressed. Also, one's appearance is bad. 5. Wounds often fester when entirely protected from the air. Anaerobic bacteria (as those which cause tetanus or lockjaw), which can live only where there is no free oxygen, may thrive in the wound and produce toxins. 6. Iodine kills bacteria, thus preventing infection.

UNIT VIII

Unit Objectives: (1) To give an understanding of the various ways in which living things are reproduced. (2) To illustrate how knowledge is advanced through scientific investigation. (3) To develop a clear understanding of the laws of heredity. (4) To teach some of the applications of laws of heredity to human problems. (5) To give an understanding of the procession of living things through the ages.

Chapter XXVII

Figure, top of page 543. That earthworms rain down; that goose barnacles turn into geese; that horsehairs placed in water become snakes; also, each locality will provide many other such fallacies.

Figure, bottom of page 543. The young plant lice are very small and are likely to escape notice until they are almost adult. Then the rounded glistening bodies sometimes look like shining dewdrops. The plant lice and the dew are found together on plant stems. Also, plant lice excrete a liquid which somewhat resembles small drops of dew.

Figure, p. 544. Each jar served as a control for the other two. Any kind of organism or matter which might float in the air had free access to the first jar; the second was protected against organisms too large to enter the gauze; the third did not permit the entrance of organisms or of air.

Figure,.p. 545. The water seal in the bend of the tube was a more certain method of insuring that nothing could enter the flask than the parchment, which might have been thought to be more or less porous. Also, there might be on the under-side of the parchment cover some dust containing living organisms, which might fall into the infusion.

Experiment 60, p. 546. The tubes that have been stoppered show no change in appearance, while the liquid in the tubes that have been opened is cloudy and ill-smelling. Scientific Method: The controls were the unopened tubes. They were necessary in order to make the opening of the tube the experimental factor. Each location served as a control for the rest in demonstrating that the results of the experiments were not merely chance occurrences and were not due to any particular location.

Figure, p. 546. The last step served as a control in showing that there was nothing in the nature of the contents of the tubes which prevented spoiling when air was allowed access to them.

Self-test, p. 547. 1. R. 2. (1). 3. Tyndall, Pasteur, Redi.

Figure, p. 548. Assimilation of food, with resulting cell growth, reproduction of cells, and resulting increase and enlargement of tissues and organs.

Self-test, p. 549. 1. R. 2. Transpose sexual and asexual. 3. Change no to many. 4. R. 5. Change many to two. 6. Change two to one.

Figure, p. 550. One bug can reproduce, which means that one overlooked pest is able to produce many new individuals and soon reinfest a host plant.

Figure, p. 551. *Pleurococcus* cells may remain in groups after fission has occurred. In *Spirogyra* the division of the cell takes place transversely, thus increasing the length of the filament. When fission occurs in *Amoeba*, the two newly formed cells separate. The process of fission in *Hydra* divides the animal longitudinally. Bacteria are often found in chains because like some of the *Pleurococcus* cells and like *Spirogyra* the cells do not separate after fission. Conditions which would be favorable to fission are plenty of food, warmth, moisture, and oxygen.

Figure, p. 552. *Similarities*: Both budding and fission tend to produce new individuals. *Differences*: Fission is equal division of the parent; budding results in unequal division, that is, the parent cell produces on one side the bud which becomes a new individual.

Self-test, p. 552. *1*. Change *one* to *neither*. *2*. Change *budding* to *fission*. *3*. Change *fission* to *budding*. *4*. Change *budding* to *fission*. *5*. Change *no* to *few*.

Figure, p. 553. It has four distinct methods of reproduction: three asexual methods and a sexual method.

Self-test, p. 554. *1*. Change *all* to *many*. *2*. *R*. *3*. Change *odd* to *even*. *4*. Change *one* to *none*.

Figure, top of page 555. The amount of food material which the developing plant could use to start its growth determined the size which it could attain at this stage in growth. The plants were grown under identical conditions except for the experimental factor, which was the size of the cutting used. Each plant was therefore a control for the others.

Figure, bottom of page 555. The seven-headed hydra might have been produced by cutting into the animal longitudinally and preventing the cut from growing together. This cut would produce the first fork. Then further cuts would produce the other heads.

Figure, p. 556. Man and other mammals regenerate hair, skin, tissue, parts of bone, and nails or claws. Birds regenerate feathers.

Figure, p. 557. Cleft grafting consists in placing twigs which are cut obliquely, so as to expose the cambium, in the cleft end of a branch in such a position that the cambium layers of the two are in contact. The wound is then sealed with wax to prevent evaporation and to prevent entrance of insects and fungi. Whip grafting is used when the scion and the host are of nearly the same size. The grooves are cut in the two twigs in such a way that they will not readily slip apart. Budding is described on page 558.

Figure, p. 558. Plants A and B served as controls for each other, showing that the experimental factor (the chemicals) produced the differences. In the same way C and D served as controls for each other.

Figure, p. 559. The Y-shaped earthworm may have been produced by grafting an extra tail to a whole worm. The other may have been produced by grafting two heads or two tails together.

Self-test, p. 560. 1. Change generation to regeneration. 2. R. 3. Change mollusks to annelids. 4. R. 5. Change fishes to mammals. 6. R. 7. Change birds to man.

Self-test on Mastery of Facts, p. 560. Similarities: All are asexual methods, that is, only a single parent organism is necessary to produce the offspring. Differences: fission results in two cells of equal size; budding results in an unequal division, with the offspring smaller than the parent; spore formation consists of several successive divisions, resulting in many small cells from the original parent; vegetative reproduction occurs in many-celled organisms when some group of cells develops to form a new organism like the original.

Fundamental Generalizations, p. 560. 1. To support the principle "Man's ideas of what is true change as more facts are learned," we have the stories of belief in spontaneous generation and the experiments which gradually disproved this theory. That "scientific knowledge grows slowly" is shown by the fact that scientific investigation of the theory of spontaneous generation continued from the time of Redi in the 1600's until the time of Tyndall in the 1800's. That "scientific truth is built up by means of many small additions" is shown by the fact that many men contributed to the information which served to overthrow the theory of spontaneous generation. That "scientific progress is not always steadily forward" is shown by the fact that Buffon in the eighteenth century was still arguing in favor of the theory of spontaneous generation, in spite of the conclusive work of Redi a century earlier. 2. An animal which is able to regenerate lost parts is better able to carry on its life activities than it would be without those parts. 3. Evidence which indicates that "life springs only from life" is found in the experiments with infusions. When they were protected from dust, no life appeared; but when dust was admitted, living things appeared in the infusions.

Problems, p. 561. 1. Classes of chordates are Pisces, Amphibia, Reptilia, Aves, Mammalia. Phyla which may reproduce both asexually and sexually: Protozoa, Porifera, Coelenterata, Echinodermata, Annelida, Arthropoda. 2. Lack of food, oxygen, and moisture; presence of wastes which act as poisons; presence of enemies; crowding in the available space. 3. Such spores could be carried great distances in a short time and probably could become distributed to most parts of the world. 4. Similarities: Both processes produce new individuals by the division of a parent cell. Differences: In fission the cells are usually free to separate when the division is complete; in the spore production of the yeast the cells are kept for a time within the surrounding wall. In fission the process may go on indefinitely. In the case of the yeast division stops when eight cells have been formed. 5. No. The Baldwin-apple branch would continue to produce Baldwin apples. The tree to which it is grafted supplies water and minerals from the soil, but does not change the nature of the cells in the branch. Therefore no new kind of apple could be produced.

Exercise on Scientific Attitudes, p. 561. Lack of attitude 2 is shown by those who believed that inorganic matter could spontaneously give rise to life. Attitudes 6, 7, 8, and 9 are illustrated in Pasteur's careful experimentation. Lack of 11 is shown by those who refused to accept Pasteur's proof; those who accepted his conclusions illustrate this attitude. The story of the entire controversy illustrates 5.

Exercise on Scientific Method, p. 561. 1. The starfish halves could regenerate entire new animals. A more effective method of getting rid of the starfish might be to throw them upon the beach, where, out of water, they would soon die. Oyster farmers now burn the captured starfish in huge piles on the beach. 2. The oak tree and the apple tree belong to widely different genera. (The reason why such grafts will not grow is not entirely understood, but probably the enzymes or the hormones or other chemicals produced by the cells are so different that neither kind of cell can grow when close to the other.)

Chapter XXVIII

Figure, p. 564. Conjugation of Spirogyra is described on pages 563-564. Spirogyra reproduces vegetatively by fission, and sexually by spore production following conjugation.

Figure, p. 565. In conjugation of Paramecium (left) the entire organism takes part, while in Ulothrix only certain cells formed by the plant reproduce it. With Paramecium the two individuals conjugating remain distinct and separate after exchanging nuclear material. With Ulothrix the conjugating cells unite to form one reproductive cell.

Self-test, p. 565. 1. R. 2. Change seldom to never. 3. Change different to alike. 4. Transpose female and male.

Figure, p. 566. They are both complete and perfect, since they contain not only the reproductive organs but also the petals and sepals.

Figure, top of page 567. The form and surface markings of pollen grains differ widely in different kinds of plants.

Figure, bottom of page 567. The explanation is given on page 567. (The figure does not show the development of the male gametes within the pollen tube, nor the egg within the embryo sac. A good class exercise is to have pupils draw a figure similar to this one, but to include in it more details, following the description carefully.)

Figure, p. 568. Flower B. The enlarged lower part of the pistil.

Figure, p. 569. Self-pollination occurs when pollen from the stamens of a flower is transferred to the stigma of the same flower. Cross-pollination occurs when pollen is transferred from the stamens of one flower to the stigma of another flower.

Self-test, p. 570. 1. Change pistils to stamens. 2. R. 3. Change spore to seed. 4. Change self to cross. 5. Change self to cross. 6. See the five points on page 569.

Figure, top of page 571. Tapeworm, Hydra, and such mollusks as the common snails.

Figure, p. 572. The eggs from which no embryo is developing were not fertilized.

Self-test, p. 572. 1. Transpose arthropods and coelenterates. 2. Change self to cross. 3. (2).

Figure, p. 573. In the plant ovary on the left the ovules are attached to a placenta which extends from three points on the sides of the ovary and meets in the center. In the one in the middle the placenta extends upward from the stem through the center of the ovary. In the ovary at the right the placentas are attached at three separate places on the walls. Similarities: The mammal embryo is like that of the seed in that it develops within the protection of the parent organism, and is attached to the parent (mother) by a placenta, through which it obtains nourishment. Differences: The development of the mammal embryo is continuous, while the plant embryo usually goes into a resting stage within the seed; the mammal embryo develops, not in the ovary, where the egg was produced, but in a special structure, the uterus; the mammal embryo is surrounded by a fluid, while the plant embryo is surrounded by nourishing tissues.

Figure, p. 574. Because these three are mammals and thus more closely related to one another.

Figure, p. 575. Opossum, wallaby, koala.

Figure, p. 576. Second day: a spot which shows something is developing (the heart can be seen as a pulsating red spot about the size of a pinhead). Fifth day:head, general body form, blood vessels. Tenth day: head clearly shown, eye, limbs budding from main body. Fifteenth day: body form clearly shown, bill, wings, and legs. Twenty-first day: feathers developed.

Figure, p. 577. A one-celled animal, such as the paramecium, does not pass through any stages comparable to those beyond the fertilized egg of higher animals. Volvox, in reaching the many-celled hollow-ball (blastula) stage which is its natural form, passes through several stages beyond the one-celled form. The hydra never passes beyond the two-layer (gastrula) stage. A still higher animal, such as the earthworm, passes through all the stages shown to attain the three-layered body with specialized organs.

Self-test, p. 578. 1. Change chicken to mammal (also true of fish and amphibians). 2. Change less well to much better. 3. Change large to no. 4. R.

Figure, p. 579. See pages 578-579. A shows spores being scattered from a ripe spore case. B is the thread-like protonema, which produces leafy buds, as in C. At the tips of these leafy stems the sex organs (E and F) are produced. Sperms from F fertilize the egg in E. This fertilized egg begins to grow, producing the sporophyte, G. D is the gametophyte; G (the part above the leaves) is the sporophyte.

Experiment 61, p. 579. Suggested activity: As one observes a fern sporangium, he may see a cellular band extending about three-fourths around the capsule (see the figure on page 580). When the spores are ripe, this band (annulus) slowly bends outward and then reacts quickly, thus throwing the spores from the sporangium. The brick must be kept moist; but do not pour water on it, because the spores would be washed away. Too much light will kill the delicate young plants.

Figure, p. 580. A spore germinates to produce first an alga-like growth and finally the heart-shaped prothallium. On the under-surface of the prothallium the male and the female sex organs are produced. Sperms are released by the male sex organ and fertilize the eggs. The fertilized egg develops into a leafy plant. The leaves of this plant bear on their under-surfaces sporangia, which produce asexual spores. These in turn produce prothallia.

Color plate facing page 580. The migrations of the salmon are unlearned reactions and are performed by all the fish in the same way. The fishermen have learned, either through their own experiences or by watching someone else, how best to catch the fish.

Self-test, p. 581. *1*. Transpose *parent* and *grandparent*. *2*. *R*. *3*. Change *sex organs* to *spore cases* (or *sporangia*). *4*. Change *gamete-bearing* to *spore-bearing*.

Figure, p. 583. The paper wasp makes its nest by scraping lint from exposed wood and then building the moistened lint upon the object which supports the nest. The leaf-cutter bee fastens the leaf sections together to form a capsule, in which an egg is placed.

Self-test, p. 583. *1*. Change *lower* to *higher*. *2*. *R*. *3*. Change *fresh* to *salt*. *4*. *R*. *5*. Change *spring* to *winter*; change *after* to *before*.

Figure, p. 584. The stickleback builds a nest to shelter the eggs, and guards them until they hatch. Because of this protection the young have a better chance for survival than would be true of unprotected offspring.

Figure, p. 585. The young of the geese are less helpless when hatched than those of the kingbird and the swallow. One principle might be "Birds the young of which are able to run about when first hatched build less substantial nests than do those birds that care for their helpless young."

Figure, p. 586. No. The squash bug instinctively lays the eggs on a plant which will serve as food for the young, but it does not remain with the eggs or care for the young.

Figure, p. 588. Reproduction is shown by the adult and young. Growth by the marked difference in the size of the two. Change by the differences in color markings, general shape, and size.

Self-test, p. 589. *1*. Change *rarely* to *never*. *2*. Change *no* to *some*. *3*. Turtles. (A few snakes make nests.) *4*. Change *mollusks* to *insects*. *5*. Change *reptiles* to *fish*. *6*. *R*.

Self-test on Biological Principles, p. 589. *1*. Lower animals, such as oysters and fish, produce vast numbers of eggs and sperms, most of which will not produce mature animals. *2*. Only the sperms which are strong enough to reach the egg promptly are likely to survive; the weaker sperms will die. The advantage which the plant or animal gains from such waste of life is that the offspring is more likely to be a successful organism if it is produced from the more vigorous germ cells. *3*. An oyster may produce a million eggs, but pays no attention to them after they are laid. A fish like the stickleback produces from fifty to a hundred eggs, which are placed in a nest and guarded from harm. A robin lays three or four eggs, incubates them, feeds the helpless young, and guards them against dangers. Man produces few offspring, usually one offspring at a time, which he cares for through many years. 4. The weaker fish are unable to survive the difficult journey upstream against the current and the necessity of leaping waterfalls. Only the fittest reach the spawning grounds. 5. The a statements are examples of "teleology" and are commonly found in pseudoscientific literature. Teleology assumes that organisms possess the structures they have for the definite purpose of accomplishing their work. Biologists do not accept this assumption. They believe that, if an organism chances to possess a structure which aids it in survival, that organism is more likely to survive and reproduce than other organisms of the same kind which do not chance to possess the favorable structure. Thus the b statements are considered by biologists to be correct because, in the first instance, those seeds which survive and reproduce are the ones which have hooks and which therefore are best fitted to catch into the fur of passing animals. In the second instance, the animals which have protective coloration, and are therefore fitted to their environment, are the ones which live and reproduce. The seed hooks and the protective coloration are not something they adopt purposefully.

Problems, p. 590. 1. The resting spore formed by conjugation in Spirogyra enables the plant to live over winter and through drought. The sexual spores are an advantage in that an added vitality is given the plant because of the union of two cells. 2. Each of the structures named has developed from the ovary of a flower and is a ripened ovary together with its inclosed seeds, also with such other structures as may ripen with the ovary. 3. Currents of water caused by the wind or by the swimming of other animals might prevent the sperms from reaching the eggs. 4. Interesting examples of adaptations for cross-pollination by wind may be observed in the spring when catkin-bearing trees, as willow, walnut, birch, cottonwood, and alder, are in flower. Such flowers as sweet pea or snapdragon show adaptations for insect pollination, since the irregular, closed flower can be forced open only by a heavy-bodied insect. In reference books pupils can readily find accounts of the activities of a certain wasp in pollinating figs and of a moth in pollinating yucca flowers. 5. The stickleback and the dogfish care for the eggs and the young, while cod and eels do not. A larger percentage of the eggs laid will therefore probably develop into mature sticklebacks and dogfish. 6. When the eggs hatch, the young are more likely to be able to find food; also, the weather will be warmer and therefore more favorable in the spring than in the fall. 7. Similarities: Both birds' eggs and frogs' eggs require warmth and moisture for incubation. Differences: The bird embryo develops within a shell; it must have a high temperature, as furnished by heat from the body of the hen or from an incubator. The frog egg is enclosed in a membrane only; it incubates at a rather low temperature.

Exercises on Scientific Method, p. 590. 1. This is parental care in so far as the body of the parent does shelter the young during part of their development. It is not true parental care in the sense that we observe in higher animals, since the clam does not seem aware of the offspring to the extent of providing food for them. 2. The plants may depend for pollination on some insect or other animal that is not present in the new region; some substance needed in the fruit may be lacking in the soil of the new habitat.

Chapter XXIX

Figure, p. 592. Slight differences in the shape or structure of the head, legs, or other organs; differences in amount or distribution of hair; differences in rate of growth; other small differences in reaction to the environment.

Figure, p. 593. No. The modern horse has long slender legs best fitted for running on firm ground; the primitive horse, with the widely spreading toes, was fitted for traveling over swamps and bogs as well as over somewhat more solid ground.

Figure, p. 594. If its offspring should inherit the characteristic of six-leggedness, the frog would be a mutant (sometimes called a sport); when such unusual characteristics are not inherited by the offspring, the organism possessing the unusual characteristics is known as a freak.

Figure, p. 595. The young raccoons have inherited the peculiar character of the mother, that is, white fur, which is not normal for raccoons; therefore this is a color mutation.

Figure, p. 597. Differences in soil, in the amount of cultivation given the plants, in the amount or kind of fertilizer added to the soil, and in the spacing between the plants. In the right-hand plot the plants are crowded closely together.

Self-test, p. 597. 1. Change often to never. 2. R. 3. Change never to often. 4. Change hybridizations to mutations. 5. Change mutations to variations. 6. Change likely to possible. 7. Change mutant to hybrid. 8. Change little to much or considerable. 9. Change little to much.

Figure, p. 598. Yes (except in the case of plants or animals which have been reproduced vegetatively). "New living things come only from living things" (No. 33). Another principle that might be stated is "All plants and animals, whether one-celled or many-celled, begin their individual life as a single cell."

Figure, p. 599. The chromosomes are the long strands; what are thought to be the genes appear as light or dark bands across the chromosomes.

Figure, p. 600. That one chromosome contains genes for many characters; that corresponding parts of different chromosomes contain genes for related hereditary characters.

Figure, p. 601. Before mitosis begins, the chromatin is scattered throughout the nucleus (1). The chromatin granules unite to form a thread (2). This thread separates into short rod-like sections (chromosomes), and these are soon arranged across the middle of the cell (3). Each chromosome now splits lengthwise, and the halves are then drawn to opposite ends of the cell (4), (5), and (6). A dividing wall starts to form across the center of the cell (7). The chromosomes unite to form a chromatin thread (8). Finally the dividing wall is complete, and the two new cells are separated (9).

Figure, p. 602. Identical twins have developed from a single fertilized egg, which became separated into two parts early in development. The fawns, as long as they remain quiet, are so well protected by their color and their absence of odor that enemies are not likely to find them; also, if they remain in the same spot, the mother will have no difficulty finding them again.

Self-test, p. 603. 1. R. 2. R. 3. Change chromatins to genes. 4. Change different to the same; change from to as. 5. Transpose chromosomes and genes.

Figure, p. 604. One significant fact that can be emphasized in the report is that Mendel carried on his experiments for years because of his great interest in the study; and, while he wrote very complete accounts of his observations, his conclusions commanded very little attention from the scientific world until years later when his papers were rediscovered.

Color plate facing page 604. They illustrate the law of segregation, since in the F_2 generation one fourth of the offspring are pure dominant, one fourth are pure recessive, and one half are hybrid. The white organisms are pure-bred for that color; they inherited from their hybrid parents only genes for white. If they carried any genes for a darker color, that color would show, since it is dominant over white.

Figure, p. 605. With peas smoothness is a dominant character. Therefore all the F_1 generation have this character. In the F_2 generation three fourths of the offspring show the dominant trait, and one fourth show the recessive trait, or wrinkledness. With cattle hornlessness is the dominant character, as is shown by the fact that the F_1 generation are all hornless. The F_2 generations of both peas and cattle show the usual ratio of three fourths of the offspring with the dominant character, while one fourth has the recessive character.

Figure, p. 606. Illustration of 3, b

	T	T
T	TT	TT
t	Tt	Tt

Illustration of 3, c

	t	t
T	Tt	tT
t	tt	tt

Self-test, p. 608. 1. Mendel. 2. Change one half to none of; change one half to one fourth. 3. Change will to may. If the cats should be hybrids, it is possible that the recessive lighter colors might show in the offspring. 4. Change impossible to possible (incomplete dominance). 5. Change some to no. 6. Change little to no.

Figure, p. 609. Tomato, potato, corn, cabbage, grapes, oranges, and grapefruit.

Figure, p. 610. The ancestors of Man o' War, as well as his offspring, possessed traits which enabled them to become famous race horses. Note that Man o' War, the greatest of the group, inherited the desired characteristics from both parents.

Figure, p. 611. Three of the four children of the first marriage were feeble-minded. One of the feeble-minded daughters (left), who married a feeble-minded man, had only feeble-minded children. The marriage of two normal people resulted in normal children.

Figure, p. 612. These children resemble one another in many respects because physical and mental traits are inherited. These children are all obviously feeble-minded. They have feeble-minded ancestors; and if they should have descendants, some of these in later generations are practically certain to be feeble-minded. Feeble-minded stock is a certain source of at least some feeble-mindedness in later generations. It is therefore essential that people know the ancestry of those whom they think of marrying.

Self-test, p. 613. 1. R. 2. Selection and propagation of desirable types; crossbreeding to secure new desirable types and the elimination of undesirable types. 3. See page 612. 4. R. 5. Change only to both; change or to and. 6. Transpose inheritance and environment.

Exercises on Biological Principles, p. 613. 1. Examples of mutations are white rats and mice, hornless cattle, rust-resistant wheat, seedless oranges. 2. In guinea pigs black hair is dominant over white hair; in man darkness of eye color is dominant, and lightness of eye color is recessive. In man neither tallness nor shortness is completely dominant, with the result that offspring of one tall and one short parent are often average in height. 3. Living things always resemble their ancestors in many ways, indicating that they have inherited certain characters from those ancestors. Since, however, they inherit characters from many ancestors, those characters are not always associated in such a way that the individual closely resembles any one of its ancestors. 4. No, the statement could not be true. "Unit characters will breed true from generation to generation if the parent stock is pure for this character."

Problems, p. 614. 1. All of the F_1 generation will be white, since white is dominant. They are hybrids. The offspring in the F_2 generation will be in the proportion of three white pigs to one black one. It is asserted by some scientists, however, that there are exceptions to this rule of white dominance in hogs. 2. In the F_1 generation all the calves of dominant-black and recessive-white parents will be black. If two of the F_1 generation are mated, the calves of the F_2 generation will be in the ratio of 3 black to 1 white. (All the rest of these problems would be similarly solved.) 3. Cross-pollinate dwarf white flowers and tall red flowers. Plant the seeds thus produced. If they are cross-pollinated with each other, from the seeds all kinds of combinations of the four characters will be produced: short plants with red flowers, short plants with white flowers, tall plants with red flowers, and tall plants with white flowers. All except the tall plants with red flowers should be destroyed. But most (three fourths) of these tall plants with red flowers are hybrids. One would therefore have to continue the cross-pollinating and the elimination of the undesired types until, for several generations, only tall plants with red flowers were produced. 4. When a characteristic "skips a generation," it does so because that generation possesses a corresponding dominant character which hides the character said to be skipped. Yes, it might skip two or three generations, because in each case the individuals could be hybrids showing only the dominant character but at the same time carrying genes for the recessive character. If then two individuals, each bearing this recessive character, were mated, the offspring might possess the recessive character which had not appeared for several generations. 5. It is a mutant, since the characteristic is inherited. 6. By crossbreeding an individual having that character with another individual possessing a contrasting character. If the character under observation appeared in a large number of offspring generation after generation, it would be a dominant character. 7. The brown-eyed parents may be hybrids for eye color; that is, they may both carry genes for blue eye color. In such a case their children might have the recessive trait of blue eye color. 8. This chart can be made by using the plans used in the figures on pages 610 and 611. 9. Such a plant as corn which can be grown in the colder northern regions was unknown a hundred years ago. This variety was secured by selection of those ears which matured earliest, planting them where the plants could be pollinated by similar plants only, reselection in succeeding years of those which matured early.

Chapter XXX

Figure, p. 617. The fern print is the impression of a leaf which was pressed between layers of coal-forming material. We know that the climate of the region where it grew must have been warm and moist. The shells in the rock indicate that the region in which this rock was found was once beneath the surface of the ocean.

Figure, pp. 618-619. Probably many of the animals wandered into the tar when they were seeking water or rushed into it when escaping from enemies. The flesh-eaters may have been attracted by the helpless prey and were caught and held by the tar.

Figure, p. 620. There is evidence in this picture to support principles 1, 2, 5. The geologists state that parts of New York State were submerged by the ocean and subsequently were elevated above it. This occurred three different times, millions of years apart.

Figures between pages 621 and 622. A "missing link" is sometimes believed to indicate the common ancestor of men and the higher apes. If such a thing ever existed, it doubtless could have been but one of several or many so-called "missing links." "Missing link" is applied to any animal or plant which may be a common ancestor of forms now living but of which no fossils have yet been discovered. The term really means a missing organism or group of organisms in the chain of development from ancient, more simple forms to modern, more complex forms.

The volvox, like Euglena (p. 304), has characteristics of both plants and animals. It has chlorophyll, like the green plants, and has certain cells which can capture food, like an animal.

Figure, p. 622. The chart shows that there has been a progressive development of plant and animal life from at least half a billion years ago to the present; that each of the geological periods is characterized by certain types of animals and plants; that the most ancient known animals were all simple as compared with the highest of the present day; and that the whole time during which men have been on the earth is only about two tenths of 1 per cent of the time that life is known to have existed.

Self-test, p. 623. 1. Shells, bones, or other hard parts; entire animals preserved in ice or amber; petrified remains; prints, as leaf prints or footprints; casts of shells or other parts. 2. R. 3. Exchange large and small. 4. Change no to many. 5. The structures of present-day organisms resemble the corresponding structures of plants and animals now extinct closely enough to indicate relationship. Along with the fossils of extinct organisms which are different from any now living are found other fossils of organisms which are practically identical in size and structure with organisms now living. There is in general a progressive increase in complexity of structure of living things, as shown by the fossil evidence, from ancient geological periods to the present. 6. Exchange animal and plant.

Self-test on Biological Principles, p. 623. If the pupils find difficulty in locating materials substantiating any of these principles, the following references to some of the supporting evidence may prove helpful: (1) The figure on page 622 furnishes evidences supporting this principle (see also pages 246-247 for evidence outside this chapter). (2) Most of the figures in this chapter (see also pages 246-247). (3) The figure on page 622 traces life back only half a billion years, though much older strata are known in which no evidences of life have been discovered. (4) The figure on page 622. (5) A number of the figures, particularly the one on page 622. (6) The figures on the two pages following page 621. (7) Especially the figures on the two pages following page 621. (8) The figure on page 622.

Problems, p. 623. 1. Examples will vary with different parts of the country. Gravel beds are the remains of ancient lakes or river deposits. Shale is hardened layers of mud. Fossils of mollusks or other water animals may be found in places that are high above present water levels. 2. In bodies of water where shells of animals sink to the bottom; where plant or animal parts are preserved from decay by being submerged in water and then covered with layers of sand or mud; where the remains of plants or animals are subjected to the action of mineral-bearing water and may therefore become petrified.

BIOLOGY FOR LEISURE TIME

Figure, p. 631. A net, cyanide jar or other killing bottle, collecting bottles.

Figure, p. 632. Some animals place each foot in a separate spot, as the rabbit or the squirrel; others place the hind foot in the print of the front foot, as the fox and the cat. Some animals walk or run, making a track first right, then left, as does the cat; others jump, leaving tracks of all four feet close together, as the squirrel. Birds may walk, as the quail, or hop, as the sparrow. Some animals walk with only the ball of the foot and the toes touching the ground, as the cat; others walk flat-footed, as the raccoon.

Figure, p. 633. Phoebe, wood pewee.

Figure, p. 634. In open wooded regions and in old apple trees. Often they climb up and down the trunks of trees, seeking insects, but they feed largely on the ground, eating ants; they nest in high hollow trees or in holes they make in trees and telephone poles.

Figure, p. 637. Frogs, fish, water striders, back swimmers, water scorpions, whirligig beetles, diving beetles, midge larvae, mosquito larvae, snails, crayfish. They are making careful observations (5) and perhaps locating problems for study (1). Probably they are making some inferences from their observations (7).

Figure, p. 639. A killing bottle, collecting bottles.

Figure, p. 640. No, mushrooms of the genus Amanita are nearly all very poisonous.

Figure, p. 641. The animals will supply carbon dioxide for the plants to use in food-making. The fish will eat mosquito larvae. The snails and tadpoles are good scavengers.

Figure, p. 643. Paramecium, digestive system of frog, the process of conjugation, etc.

Figure, p. 647. The silkworm is not found wild in any part of the world today. It depends entirely on man for protection and care. The silkworm has complete metamorphosis -- egg, larva, pupa (in the cocoon), and adult. An added picture would show the moth which came from the cocoon.

Figure, p. 648. One would acquire firsthand knowledge of the structure of the animal used. He would have the basis for determining taxonomic relations.

Figure, p. 649. Squirrels, rabbits, and raccoons make good pets. So do white rats and mice. Other rodents are not so desirable or are not so easily tamed.

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TEACHERS' KEY TO WORKBOOK FOR EVERYDAY BIOLOGY

ANSWERS TO QUESTIONS AND SUGGESTIONS CONCERNING MATERIALS IN THE WORKBOOK

LABORATORY EXERCISE. Making Drawings

Fig. 7 is an acceptable diagram because it gives the idea of the general location of bundles in any dicot stem. It would not serve as a sketch because it does not show the general shape and relation of parts. It is not detailed enough for a drawing.

Fig. 8 is an acceptable sketch because it shows clearly certain facts concerning the shape, size, and location of structures, without going into great detail.

Fig. 9 shows details of tissues, relation of parts, and shapes of cells as they appear under the microscope. It is carefully and exactly done and represents the actual specimen observed.

EXPERIMENT 2. Oxygen

The glowing splint bursts into flame in oxygen. Oxygen does not burn, but it causes burning to go on more rapidly. It has no color.

EXPERIMENT 3. Carbon Dioxide

The presence of carbon dioxide causes limewater to become milky. Carbon dioxide extinguishes a lighted splint or a glowing splint. The gas has no color.

Questions for Study (pp. 14-21). *1*. Food, heat, oxygen, water. *2*. Life cannot exist at extremely low or extremely high temperatures. *3*. *Fresh water*: minnow, tadpole. *Salt water*: starfish, coral. *Either*: salmon, eel.

Questions for Study (pp. 21-27). *1*. *Food*: cow, dog. *Heat*: bean plant, polar bear. *Light*: bean plant, geranium. *Oxygen*: dog, man. *Carbon dioxide*: any green plant. *Weather*: peach tree, wheat. *Climate*: elephant, polar bear. *Water*: fish, water lily, cactus. *Shelter*: young child, young bird. *Soil*: oak tree, corn plant. *2*. They must gradually have changed, too, to become adapted to a drier environment. *3*. *Cave*, bear; *nest*, robin; *hollow tree*, woodpecker; *cocoon*, silkworm; *house*, man; *bodies of other animals*, tapeworm; *stems*, gall insects; *burrow*, earthworm. *4*. *Wolf*: ocean, desert, mountain range (perhaps). *Song bird*: desert, ocean (if distance across to land is great). *Frog*: ocean, desert, forest, plains, mountains, rivers (if wide). *Lawn grass*: river, desert, mountain, ocean, and forests (perhaps). *Maple tree*: ocean, desert, mountain, plains, forest (if of other trees). *Butterfly*: ocean, desert, mountain. *5*. *Similarities*: In both cases the two animals live in close association.

Differences: Both the crab and the hydroids derive some benefit from their association; in the other case only the flea is benefited, while the dog is injured. 6. Hollow trees are used to hide in or for nests; branches support nests, and leaves hide them; animals climb into trees to escape animals that cannot climb; trees shade plants or animals. 7. Present: food, water, oxygen. Not present: light, sufficient heat. 8. Water: fish, lobster, clam. Mountains: mountain goat, puma. Desert: cactus, horned toad, camel. Swamps: cat-tails, frog. Jungles: tiger, elephant. Arctic regions: polar bear, seal. Plains: grass, horse, buffalo.

Exercise on Biological Principles, p. 10. Numbers 4, 5, 6, 7, 8, 12, 15, 21, and 40.

EXPERIMENT 4. Cells

Onion-skin cells are like the one pictured in having cell walls inclosing the cell contents. They are, however, longer in proportion to the width and are more irregular in shape. Internal structures are the same. (Pupils, however, will seldom be able to see more detailed structures until they become more accustomed to using the microscope.)

EXPERIMENT 5. Green Cells

In Elodea cells one can usually observe the chloroplasts moving in a regular fashion around the edge of the cell. (If this phenomenon is not occurring, put the plants in bright sunlight for ten minutes or so.)

Green cells are like those of the onion in possessing cell wall, cytoplasm, and nucleus. They differ in possessing chloroplasts in addition.

Questions for Study (pp. 29-35). 1. Protoplasm is jellylike, elastic, transparent (or sometimes opaque), usually colorless or slightly yellow, granular or frothy. 2. Producing others of its kind: reproduction. Securing food energy: nutrition. Getting rid of wastes: excretion. Breathing and using oxygen: respiration. Responding to light, etc.: irritability. 3. Every cell is composed of protoplasm and has a nucleus or nuclear material and cytoplasm; tissues are composed of like cells; organs are composed of several tissues. 4. A cell is a unit of protoplasm consisting of nucleus and cytoplasm and usually surrounded by a cell wall. 5. The cell theory states that all living things are composed of cells.

Questions for Study (pp. 36-42). 1. Living things have definite form, are of limited size, are made up of cells, are made up of only about ten of the elements, are irritable, grow in all parts, reproduce, can move of their own accord, use food and oxygen, give off wastes. 2. Element: oxygen, iron, hydrogen, sulfur, etc. Compound: protoplasm, water, carbon dioxide. Mixture: salt water, soup, air. 3. Organic: protoplasm, milk, beefsteak, coal, tree. Inorganic: glass, iron, lime, sand, water. 4. Carbon, hydrogen, oxygen, nitrogen, sulfur. 5. OCHNS.

Exercise on Biological Principles, p. 14. Numbers 3, 16, 22, and 29 are the best.

EXPERIMENT 7. Osmosis

The molasses and the water both pass through the membrane simultaneously. The water molecules are smaller and move more rapidly than the sugar molecules; therefore they pass through the membrane in greater numbers. The quantity of liquid in the thistle tube becomes greater than it was at the beginning. Some liquid is therefore pushed up into the tube.

EXPERIMENT 9. Reverse Osmosis

The level of the water in the thistle tube which is immersed in molasses becomes lower than it was when the apparatus was set up and lower than that in the other tube. In this case the water molecules could move out through the membrane faster than molasses molecules could come in. The thistle tube of water in the beaker of water was a control.

Exercise on Scientific Method. 1. The controls were necessary in order to show that it was the denser solution (the molasses) that caused the results observed, and that when the same substance (water) was used on both sides of the membrane there was no difference in the rate with which molecules passed through. Also the control shows that there was nothing about the apparatus itself which could cause the results observed. 2. The salt dissolving in the soil water results in a smaller concentration of water molecules outside the root than in it. Hence much more water comes out of the roots than passes in, with the result that the plant soon dies through lack of sufficient water in its tissues.

Questions for Study (pp. 42-46). 1. Both result in heat (and perhaps other forms of energy) and produce carbon dioxide and water as wastes. Differences: Oxidation in the furnace results in light and is more rapid than in the body. 2. Physical change: sharpening a lead pencil, making lemonade, freezing ice cream. Chemical change: rotting of wood, burning potatoes in cooking them.

Questions for Study (pp. 47-57). 1. That every living thing must constantly struggle to secure food and to escape enemies. 2. Because there is only a limited supply of energy available. 3. A cabbage plant receives radiant energy from the sun and transforms it into food energy. A rabbit eats the cabbage plant, and the energy stored in the food is transformed into the energy of movement, which the rabbit uses in running from a dog. 4. Using almost the same facts as above: A cabbage plant uses water and carbon dioxide to make food which is stored in its leaves. A rabbit eats the plant, and the food is transformed into cells of its body. Then a dog eats the rabbit, and the material which made up the rabbit is transformed into part of the dog. Finally, perhaps, the dog dies, and the matter that made up its body is returned to the soil and the air by the action of decay bacteria, partly as water and carbon dioxide. 5. Dependent plant: mold, mushroom, bacteria. Plant parasite: bacteria, rusts, mistletoe. Animal parasite: tapeworm, flea, louse. Independent plant: apple tree, geranium, corn. Saprophyte: mold, mushroom, yeast (usually, but some species of these plants are parasites). Dependent animal: dog, bird, man. 6. A cat is a complex animal. It has four legs for locomotion; it has eyes, ears, many different internal organs, etc. 7. Man shows division of labor in using his legs for walking, his hands for picking up things and writing, his eyes for reading, etc.

EXPERIMENT 10. The Parts of a Flower

(If this experiment is done in the fall, it is sometimes difficult to obtain enough different kinds of flowers to complete the exercise well. In such case, it is best to study the parts of one flower to show how it illustrates division of labor, and to postpone the rest of the experiment until a greater variety of flowers is available.) 1. Anther. 2. Ovary. 3. Calyx. 4. Stigma. 5. Ovule. 6. Style.

The parts of the flower essential for production of seeds are the pistil and the stamens.

Exercise on Scientific Principles, p. 21. The flower is composed of several different parts, each of which has a specific use.

Questions for Study (pp. 58-61). 1. (1) Enemies which take some or all the stores of energy: a parasite, such as lice on chickens; a boy who takes the nuts which a squirrel has stored. (2) Enemies which shut off or diminish the supply of energy: a tall plant shading smaller ones; weeds in a garden. (3) Enemies which kill or injure: a rabbit eating young cabbage plants; insects which kill or injure plants; a dog catching a rabbit. (4) Enemies which change the habitat: a flood; a shifting river; changing seasons. 2. Bark, thick leaves, thorns, leaves covered with hairs, bad-tasting or poisonous juices, unpleasant odors. 3. (1) Offense or defense: crayfish claws, horns, cactus spines. (2) Of skin: elephant hide, fur of seal. (3) Artificial exoskeleton: cocoon of moth, shells of some Protozoa, clothing or armor of man. (4) For speed: rapid flight of wild duck, speed of rabbit. (5) Protective coloration: toad, katydid, zebra, polar bear. (6) Products of specialized structures: poisonous secretions of toad's skin, ill-smelling smoke of bombardier beetle. (7) Ferocious appearance: porcupine raises its quills, dog bares its teeth.

Questions for Study (pp. 61-67). 1. The numbers of plants and animals and the kinds of plants and animals in a region tend to remain about the same. 2. The new plant or animal is likely to increase greatly in numbers for a time, because many of its natural enemies may be absent. 3. By clearing ground and planting crops: removal of forests, etc. By introducing new plants and animals: English sparrow, gypsy moth. By introducing pests with commerce: Hessian fly, European corn-borer. By spreading pests in his travels: corn-borer, cotton-boll weevil. By killing species harmful to himself: wolf, rattlesnake. By hunting, trapping, etc.: passemger pigeon, deer. 4. By game laws; fishing laws; reforestation; artificial propagation of fish, birds, etc,; establishment of game preserves, parks, etc.

Exercise on Biological Principles, p. 23. Numbers 2, 4, 11, 13, 23, and 24 are best.

EXPERIMENT 11. Heliotropism

Both the stems and the leaves of green plants tend to turn towards the light.

PROJECT 3. To Find Examples of Many Different Types of Leaf Margins

Pupils who undertake this project may be interested in these additional facts: Some of the terms applied to leaf margins are (1) entire, that is, smooth, as in

Solomon's seal; (2) serrate, or finely toothed, as in the elm; (3) crenulate, or wavy, as in geranium; (4) dentate, or distinctly toothed, as in the cottonwood; (5) lobed, as in the oak; (6) compound, as in the walnut; (7) doubly compound, as in the honey locust.

Deeply cut or lobed leaves may serve to let more light reach leaves that would otherwise be shaded. Also a deeply cut or a compound leaf would not be so easily torn in a wind as would a large entire leaf.

Questions for Study (pp. 70-78). 1. The leaves at the tips of branches are usually smaller. This fact is of advantage to the plant in that the lower leaves are not shaded so much as they would be by large leaves at the tips of branches. 2. (a) Spiral arrangement of leaves. (b) Opposite arrangement. (c) Rosette. (d) Lower leaves with longer petioles. (e) Upper leaves smaller than lower. (f) Mosaic arrangement (leaves fit into spaces between other leaves). (g) Climbing habit. (h) Habit of turning toward the sun. (i) Habit of appearing in early spring. 3. To make as much food as possible. 4. A deciduous tree sheds all its leaves at the end of the growing season; an evergreen tree retains some of its leaves throughout the year, shedding a few at a time. 5. The rosette habit of dandelions enables them to shade any plants growing close under their leaves, and thus to kill them.

Additional Problem, p. 26. Of our common trees, only the horse chestnut, the ashes, and the maples (including the box elder) have opposite leaves.

EXPERIMENT 12. The General Structure of Leaves

The net-veined leaves are a, b, and d. Leaf c is parallel-veined. Leaves b and d are compound.

EXPERIMENT 13. The Internal Structure of a Leaf

If at all possible it is most desirable to have at least one prepared slide for demonstration purposes. Pupils seldom can cut thin enough sections to see the internal structures clearly. It is desirable, however, to have them cut sections in order to appreciate how the slide was made, and to realize that the leaf really does have several layers of cells.

EXPERIMENT 14. Stomata

The number of stomata varies with the species of plant. That portion of a geranium leaf which can be seen at once under low power will probably show somewhat more than 50 stomata, arranged in no order. An iris leaf will show from 40 to 50, arranged in irregular rows. A live-forever will have only from 15 to 20, with large guard cells. There are always two guard cells. They usually contain chloroplasts.

EXPERIMENT (OPTIONAL) 15. Stomata

There are fewer stomata on the upper surface. The advantages of having more on the lower surface are that they are less likely to be filled with dust or clogged with standing water.

Exercise on Scientific Method (Making Inferences). 1. One should expect to find stomata about equally distributed on a vertical iris leaf, for both surfaces are equally exposed. 2. One should expect to find stomata on the upper surface of a water lily, since any found on the lower surface would be useless.

EXPERIMENT 17. Photosynthesis

The leaves kept in sunlight show the presence of starch; those kept in darkness do not.

Exercise on Scientific Method. 1. The conditions which were the same were the place in which the plants were kept, the size of the plants, the method of testing the leaves, etc. 2. The only condition which was different was the presence or absence of sunlight. 3. The leaves on the plant kept in darkness showed that it was the lack of light which gave the difference in results. 4. It is better to use several leaves, so that one may be sure the result is not just a chance occurrence.

EXPERIMENT 18. Photosynthesis

The white parts of the leaf do not show the presence of starch, while green parts do. One concludes that green parts of leaves make starch, while white parts do not.

Exercise on the Scientific Attitudes. 1. It is better to use several leaves, to be sure your results are the usual ones. 2. Scientific attitude 9.

EXPERIMENT 19. Photosynthesis

The green plant gives off a gas when placed in sunlight. This is oxygen.

The check experiment proved that there were no factors present with one plant and not with the other which might cause the results observed.

Questions for Study (pp. 79-87). 1. The remaining leaves could not make enough food to support the plant. 2. Upper epidermis: flat cells, used for protection. Palisade layer: elongate cells, placed close together. Spongy layer: rounded cells, loosely grouped together, with air spaces between cells. Veins: found in spongy layer; small tubular cells which carry water and sap. Lower epidermis: flat cells, not so large as those of upper epidermis. 3. Air passing into the leaf brings carbon dioxide for food-making and oxygen for respiration. Air passing out carries excess water vapor and the oxygen given off in photosynthesis. 4. Guard cells are bean-shaped. When filled with moisture they expand like balloons and leave an opening between the two cells. When they contain little moisture the cell walls are no longer held apart, but collapse somewhat, thus closing the opening between the cells. 5. Sunlight supplies the energy necessary to do the work. 6. The location of the factory: green plants. The rooms where the machinery is located: cells of leaves. The machinery: chloroplasts. The source of energy: sun. The raw materials: water and carbon dioxide. The sources of these materials: soil and air. The principal products: sugar and starch (carbohydrates). The waste product: oxygen. The transportation system: fibrovascular bundles. The form in which the product is transported: sugar. The form in which the product is stored: starch. 7. Food and oxygen.

EXPERIMENT 20. Transpiration

The bubble moves upward in the tube and toward the bottle. After the leaves have been removed, the bubble remains about where it is first observed. One concludes that water passes up the stem of a plant and out through the leaves.

Exercise on Scientific Method. 1. The cellophane bag shows that water which is absorbed from the bottle is given off by the leaves, not all used in the plant. 2. It was necessary to remove the leaves and repeat the experiment, to show that the leaves were responsible for the loss of water. 3. The plant stripped of leaves was a control, because in using it all the conditions of the experiment, except the leaves, were the same as before. 4. Element 3.

EXPERIMENT 21 (OPTIONAL). Transpiration

Considerable water appears on the bag inclosing the leafy plant, but little or no water on the other bag.

Exercise on Scientific Method (Inventing Experiments). 1. Set up apparatus as in Fig. 5, p. 35. Note the position of the air bubble. Then let it stand overnight, and again note the position of the bubble. Use the same apparatus and the same plant (to be sure all factors are the same), letting it stand an equal number of hours in the day. (This experiment is one which can well be done at home, and may have to be to have the hours of exposure the same.)

Another experiment which may be suggested is this: Choose a large test tube or similar straight sided container in which water levels can be easily measured. Fit it with a one-hole stopper. Insert the stem of a leafy plant through the hole, and put the stopper in the test tube. Let it stand over night, and measure the amount of water used. Then fill the tube with water again and let it stand an equal number of daylight hours.

2. Carefully remove a small plant from the soil, or use a geranium or other cutting. Insert the stem in a one-hole rubber stopper. You will need to split the stopper on one side as far as the hole to admit the plant without injuring it. Then place the roots in a test tube full of water. Make sure that the stopper fits closely in the tube and around the stem. Observe the level of the water in the test tube from time to time. Keep a daily record of the water level.

Questions for Study (pp. 87-93). 1. In transpiration water vapor is given off by plants. This water vapor condenses with other moisture in the air to form clouds. When the drops of condensed vapor become sufficiently large and heavy, they fall as rain. Soil water is taken in by roots, and the excess moisture is transpired. 2. To cut down the surface which is transpiring moisture at a time when the roots can secure little or no water. 3. Root pressure, caused by the constant intake of soil water; transpiration, which leaves less water in leaf cells than in adjacent cells; capillarity, which enables water to rise in xylem tubes; imbibition. 4. Shedding the leaves cuts down the rate of transpiration. If trees continued to transpire water rapidly at a time when the roots can secure little or no water the tissues of the tree would become so dry it would die. Then too snow and sleet have less surface to adhere to on a leafless tree, and branches are not so likely to be broken.

EXPERIMENT 22. Dicot-Stem Structure

The epidermis is usually brown in woody stems, but in very young stems it may be green. The cortex is green. The pith is very soft. The fibrovascular bundles of a dicot are arranged in a circle.

EXPERIMENT 23. Monocot-Stem Structure

The fibrovascular bundles are scattered irregularly throughout the stem.

Questions for Study (pp. 94-100).

Structures	Functions
Dicot	
Epidermis	Protection
Cortex	Protection, photosynthesis
Fibrovascular bundles	Transportation, support
Xylem	Carries water up
Phloem	Carries food down
Cambium	Growing region
Pith	Food storage
Pith rays	Lateral transportation
Monocot	
Rind	Support
Pith	Food storage
Fibrovascular bundles	Transportation
Xylem	Carries water up
Phloem	Carries food down

EXPERIMENT 24. Location of Buds

Practically all stems bear axillary buds. They are usually smaller than the terminal bud, and many of them may fall off before the leaves unfold.

EXPERIMENT 25. Buds

Bud scales are modified leaves which overlap to protect the bud against the entrance of water. There may be considerable sticky substance that holds the scales together. The heavy scales in some measure are a protection against insects, blows, and cold. In the cut bud one finds the closely folded leaves on a short stem. When a bud grows, the stem lengthens and the leaves increase in size. All parts are present in the bud. Likewise in an unopened flower bud all the parts of the flower can be distinguished.

Questions for Study (pp. 100-104). 1. Leaf bud: composed of tiny leaves on a shortened stem. Flower bud: composed of flower parts only. Mixed bud: contains both leaves and flower parts. Adventitious: growing from some part of a plant where buds are not usually found, as from the trunk of a tree or from roots. Axillary: found in the space between a leaf or leaf scar and the twig. Terminal: at the end of a twig. 2. In the spring the cambium begins growth after a dormant period. The first woody cells that are formed are large, since they serve to carry water rapidly up to the developing buds. As the season advances the cells formed by the cambium are smaller and more tightly packed together. The cylinder of summer wood is therefore less porous, though much wider, than the cylinder of spring wood. One annual ring consists of the cells from the beginning of one spring's growth to the beginning of the next spring's growth. 3. To support the leaves and flowers and to present them to the light; to carry water to the leaves, and food to the roots; to provide for growth; to support the weight of fruit; sometimes to carry on photosynthesis; to store food, and sometimes wastes; to serve as a means of propagation. 4. Stems furnish lumber, fuel, food, materials for clothing (such as rayon and linen), rubber, turpentine, drugs, flavors, etc.

EXPERIMENT 27. Roots

The secondary roots connect with the central cylinder. In a mature fleshy root the outer layer is the epidermis; the heavy ringlike layer (cortex) is inside the epidermis; the rest is central cylinder.

EXPERIMENT 29. Root Hairs

Root hairs are most numerous a short distance above the root tip. Thus new root hairs are being continuously formed as the root elongates and reaches moister soil. This fact enables the plant to secure more water than would otherwise be possible. The walls of the root hairs are very thin. This adaptation permits water to pass through readily.

EXPERIMENT 30. Rate of Root Growth

The most rapidly growing part of a root is near the tip.

EXPERIMENT 31. Underground Stems

The potato has buds, and perhaps shoots, similar to those on a tree stem. There are no roots attached to the tuber. The veins in the onion layers indicate that they are modified leaves. The small cone-shaped structure is the stem. Numerous small roots are attached to the base of the onion. There are no buds on the fleshy carrot, but there are numerous small roots.

Underground stems bear buds or branches, while roots do not. Roots ordinarily appear at only one point on an underground stem, but branch irregularly from a fleshy root.

Questions for Study (pp. 104-115). 1. Similarities: Both absorb moisture; both anchor the plant and have the same internal structure. Differences: Fibrous roots branch freely; fleshy roots store food. 2. (a) Fleshy roots: carrot, radish, turnip, beet. (b) Taproots: dandelion, carrot. (c) Fibrous roots: grass, corn, wheat. (d) Holdfast roots: ivy, woodbine. (e) Parasitic roots: dodder, mistletoe. 3. Epidermis: protection, absorption. Cortex: protection, storage of food or water, transfer of water (in a young root). Central cylinder (fibrovascular bundles): transportation of dissolved food downward and of water upward. Root hairs: absorption of soil water. 4. The rootcap protects the tip of the root as it pushes through the soil. The rootcap is composed of dead epidermal cells. The growing point, or meristem, is just behind the rootcap. 5. Leaves: cabbage, lettuce. Stems (erect): asparagus, sugar cane. Underground stems: potato, onion. Roots: carrot, beet. Seeds: bean, wheat. Fruits: tomato, cherry. 6. Fibrous. The fine numerous matted roots would hold soil from being washed away. 7. Corn has fibrous roots; bean has a taproot. 8. Animals may carry the fruit for some distance before eating it and dropping the seeds. Seeds with hard coverings pass through the digestive canal without injury. In either case the seeds are carried far from the parent plant. 9. Roots: (1) used as food directly, as radishes and turnips; (2) sugar, from beets; (3) tapioca; (4) medicines, as ginseng; (5) in fine furniture. Stems: (1) used as food; (2) lumber; (3) paper; (4) rayon; (5) dyes, as logwood; (6) medicines, as quinine and camphor; (7) rubber; (8) sugar; (9) rope; (10) clothing, as flax; (11) spices, as cinnamon. Leaves: (1) food; (2) drinks, as tea; (3) thatching; (4) fans; (5) spices, as bay leaves.

Questions for Study (pp. 118-126). 1. A scheme of classification is needed in order to enable anyone who wishes to do so to recognize or to classify an organism. 2. Phylum: one of the divisions of a kingdom. Class: one of the divisions of a phylum; a group of related orders. Order: one of the divisions of a class; a group of related families. Family: one of the divisions of an order; a group of related genera. Genus: one of the divisions of a family; a group of related species. Species: one of the divisions of a genus; a group of closely similar individuals.

EXPERIMENT 32. Algae

If Pleurococcus material is allowed to soak in water for an hour or more, the cells will be more easily seen. They are small, at best.

EXPERIMENT 33. Algae

Most of the common filamentous algae do not branch. (In this experiment it is not necessary that the specimens be identified. Few teachers can hope to learn all the algae. It is true that pupils will ask for names; and if an illustrated key is available they may be able to name their own specimens. Some pupils will enjoy undertaking a project of this nature.)

EXPERIMENT 35. Lichens

The lichen is made up of small green cells of algae (probably Protococcus) and threads of fungus. This relationship is an example of symbiosis. The alga is protected by the fungus and secures moisture from it. The fungus derives its food from that made by the alga.

EXPERIMENT 36. Bacteria

(It is not necessary for pupils to make the culture medium, though it is good laboratory experience. This experiment and experiments 38 and 39 may be started on the same day.)

EXPERIMENT 38. Molds

(Molds grown on filter paper moistened with fruit juice make excellent demonstration dishes to use with the binocular microscope.)

Questions for Study (pp. 128-131). 1. Thallophyta. 2. Fungi, bacteria, molds, yeasts, rusts, smuts, lichens. 3. Algae, fungi. 4. They can manufacture their own food. 5. They cannot make their own food, but are dependent on green plants. 6. No. They can survive only in moist situations, since they have no heavy protective walls. 7. They serve as food for small fish and other water animals, which in turn are eaten by larger fish, which man may use for food. They are the source of agar-agar, used as a culture medium, and some are used for food. Iodine and potassium may be extracted from them. 8. Mushrooms, bracket fungi, bacteria, yeasts, molds, rusts, smuts, mildews.

Questions for Study (pp. 131-134). 1. They rid the earth of the dead bodies of plants and animals; they return to the soil and the air the matter which made up those bodies, thus making it available for further use. 2. Aerobic bacteria use free oxygen; anaerobic bacteria use only the oxygen found in compounds which they break up. 3. Bacteria can live in almost any environment; they use a great variety of food substances; there is no evidence that their numbers are decreasing. 4. In the upper layers of the soil, bacteria find much organic matter which they can use for food. 5. (1) Heat, (2) moisture, (3) absence of sunlight. 6. No, the organism is one-celled.

Questions for Study (pp. 134-137). 1. Mycelia anchor the plant and absorb food materials; the hyphae raise the sporangia above the mass of food material, enabling the spores to be scattered farther; the spores reproduce new plants. 2. A saprophyte. It grew on nonliving food material (bread, fruit juice, etc.). 3. Yeasts are like molds in lacking chlorophyll and in living usually as saprophytes. They are unlike molds in that yeasts are one-celled, while molds are many-celled; yeasts reproduce by budding or spore formation within the single cell, while molds have special reproductive structures. 4. The mycelium serves to anchor the plant and absorb food. The cap produces the spores. 5 Yeasts are used in bread-making and in making alcohol. Certain bacteria sour milk, give flavor to butter, and aid in preparation of sponges, linen, tobacco, etc. Certain molds give flavor to cheeses. Certain mushrooms are useful as food.

Questions for Study (pp. 138-141). 1. Mosses and liverworts. 2. Neither. They possess chlorophyll and can make their own food. 3. They lack fibrovascular bundles, which would serve as supporting tissues and would carry water throughout the plant. They have no true root system, which would anchor the plant firmly and enable it to grow tall. 4. Mosses aid in soil formation by growing on rocky or poor soil; their growing roots break off rock particles; their decaying bodies add fertility. Mosses hold soil in place and thus prevent erosion. Peat mosses may fill up swamps and may form fuel material. 5. Ferns, equisetums, club mosses. 6. Ferns have fibrovascular bundles, true roots, stems, and leaves.

EXPERIMENT 41. Germination of Seeds

The record on time of germination will vary with different experiments. In each case the hypocotyl first breaks through the seed coat. In the bean and the radish the hypocotyl first appears above ground; in the corn and the pea, the plumule. In every case the cotyledon furnishes food to the seedling; in the bean and the radish the cotyledons develop chlorophyll and carry on photosynthesis for a time. The plumule forms stem and leaves. The hypocotyl forms roots, and sometimes part of the stem. (The bean stem up to the cotyledons is hypocotyl.) The cotyledon of the monocot seed remains below ground, digesting food from the endosperm and feeding it to the growing plant. The cotyledons of some dicot seeds (such as the bean) come above ground, help to carry on photosynthesis for a while, and finally drop off; in many other dicot seeds they remain below ground.

Questions for Study (pp. 142-147). 1. Angiosperms have true flowers, and the seeds are inclosed in part of the flower. Gymnosperms bear their seeds naked on the scales of cones. 2. Monocots have seeds with one cotyledon, stems with scattered fibrovascular bundles, leaves usually parallel-veined, flower parts in threes. Dicots have seeds with two cotyledons, stems with fibrovascular bundles in a circle, net-veined leaves, flower parts in fours or fives.

EXPERIMENT 42. Protozoa

Most cultures will contain many small Protozoa and a few larger ones that can be observed more readily. There will frequently be rotifers (see textbook, p. 14) as well, particularly in old cultures.

Protozoa usually move with a definite end forward. They may collect around food particles or around an air bubble.

EXPERIMENT 43. Paramecium

Paramecium moves by means of cilia distributed over the entire body surface. It swims in a spiral path. The body can bend somewhat as it encounters obstacles. The funnel-shaped groove (oral groove) collects food particles.

EXPERIMENT 44. Amoeba

Amoeba has no definite cell wall. Its shape therefore changes as it crawls along the bottom. Food is engulfed at the point where it touches the body wall; the protoplasm merely flows around the food particle.

Questions for Study (pp. 149-154). 1. Protozoa are found in almost any moist habitat. 2. They were probably on the grass or the hay, in cysts carried there with dust. They may have been in the water. 3. The protoplasm contracts, and a cyst is formed about it. 4. Protozoa may serve as food for very young fish and for other animals. Some cause disease, such as malaria and African sleeping sickness. Shell-bearing Protozoa may form chalk deposits.

EXPERIMENT 45. Sponge

(Such an experiment as this one will obviously take only a few minutes. It may be used at the end of a class period as part of the assignment preparation. Or the sponge and Hydra may be studied in the same period.)

EXPERIMENT 46. Hydra

Hydra usually has six tentacles. They are used to aid in securing food. The animal contracts when disturbed. There are two layers of cells in the body.

EXPERIMENT 47. Starfish

The common starfish usually has five arms, or rays. If one arm is shorter than the others, it probably is a new arm growing to replace one that was lost. The body is covered with short spines.

Questions for Study (pp. 154-158). 1. Porifera. 2. Many-celled animals, with two distinct body layers; a skeleton of spongin or silica or both usually present; body wall with numerous small pores through which water enters. 3. The young sponge does not at all resemble the adult. It is free-swimming, while the adult is attached. 4. Certain cells of the inner layer ingest and digest food for neighboring cells. The cells along the pores possess flagella to aid in maintaining a current of water. Cells of the outer layer are specialized for protection and for storing excess food.

Questions for Study (pp. 158-163). 1. Coelenterata. 2. Two-layered, radially symmetrical animals with one body opening; tentacles usually present. 3. The cells of the inner layer digest food; the tentacles aid in securing food; there are muscle cells, stinging cells, and nerve cells. 4. Neither. They secure food, as does any typical animal. 5. Since jellyfish have no skeletons, they would collapse if they did not have a medium, such as water, to support them. 6. A jellyfish produces attached forms (hydroids or polyps) which in turn produce jellyfish.

Questions for Study (pp. 164-173). 1. Protozoa, Platyhelminthes, Nemathelminthes.

Phylum	Parasite	Hosts
a. Protozoa	Malarial	Man, bird, mosquito
b. Platyhelminthes	Tapeworm	Man, dog, fish, pig
c. Platyhelminthes	Liver fluke	Sheep, snail
d. Nemathelminthes	Hookworm	Man
e. Nemathelminthes	Trichinella	Pig, rat, man
f. Nemathelminthes	Ascaris	Man, dog, pig

2. The hookworm and certain other roundworms, such as Ascaris, can go from one animal to another of the same species. The others named above require alternate hosts. 3. Those that crawl: amoeba, starfish, common flatworms. Those that swim: paramecium, horsehair snake, jellyfish. Those that are attached to a host: tapeworm, liver fluke, hookworm. Those that are attached to a nonliving object: hydra, coral, sponge.

Summary Exercise. The Simple Animals (pp. 164-173). 1. Protozoa: one-celled, usually microscopic. Porifera: many-celled, two-layered bodies with numerous pores and skeletons of spongin or silica. Coelenterata: two-layered, radially symmetrical, with one body opening; tentacles usually present. Platyhelminthes: bilaterally symmetrical, flattened, wormlike animals having body layers. Nemathelminthes: bilaterally symmetrical, rounded, wormlike animals with three body layers and a true body cavity. Echinodermata: radially symmetrical, spiny-skinned marine animals typically bearing tube feet.

Exercise on a Biological Principle, p.67. Any such facts as these are acceptable: A many-celled animal like the sponge has certain cells which do the work of food-getting and digestion, while a one-celled animal does not. The hydra has tentacles which secure food and a mouth to ingest it. The starfish has specialized tube feet which aid in locomotion.

EXPERIMENT 48. Earthworm

The earthworm usually crawls headforemost. There are thirty segments to the beginning of the clitellum. The number of segments in an entire worm varies greatly. There are four pairs of setae on each segment. They aid in crawling by bracing the worm. The mouth is at the very anterior end under a projecting lip. There are neither eyes nor ears.

Internal Structure. A partition separates each section from the next. (Some pupils find the worm very distasteful to work on. It may be well to have those pupils who wish to do so perform demonstration dissections for small groups of pupils. Often pupils who have rebelled at the idea of dissecting a worm will work well on the crayfish and the frog.)

Exercise on Scientific Method. There are no lungs or gills. The worm takes in oxygen through the moist skin. If the skin dries out, this absorption of oxygen is no longer possible, since osmosis can take place only through moist membranes.

Questions for Study (pp. 173-176). 1. Annelida. 2. Leech, or bloodsucker; sandworm (Nereis); sea mouse. 3. Bilaterally symmetrical, rounded, segmented worms with well-developed digestive, muscular, and nervous systems. 4. By making burrows which admit air and rain; by bringing to the surface lower layers of soil. 5. It attaches itself to its host only long enough to obtain food.

Mollusks. Questions for Study (pp. 176-183). 1. On land: land snail, slug. In fresh water: fresh-water mussel, water snails. In the ocean: oyster, clam, scallop, octopus, squid. 2. Soft bodies, usually inclosed in a shell; a fleshy foot used in locomotion. 3. Univalves: snail, whelk, nautilus, abalone. Bivalves: oyster, clam, scallop, mussel. No external shell: squid, cuttlefish, octopus. 4. Complete. The young is free-swimming and does not resemble the parent. 5. Clam, oyster, squid, abalone, scallop, snail: food. Clam, fresh-water mussel: buttons from shells. Abalone, certain clams: mother of pearl. Oysters: pearls.

EXPERIMENT 49. Crayfish; EXPERIMENT 51. Insects

For answers to the questions in these experiments, see this Teachers' Manual, pp. 34-35.

Questions for Study (pp. 184-203). 1. Jointed exoskeleton, all appendages jointed, three to many pairs of legs. 2. Insecta, Crustacea, Arachnida, Myriapoda. 3. Similarities: (1) exoskeleton, (2) compound eyes, (3) jointed appendages. Differences: (1) Insect has six legs; crayfish has ten. (2) Crayfish has united head-thorax. (3) Crayfish has a hard exoskeleton, containing lime. (4) Crayfish breathes by gills, adult insect by tracheae. (5) Crayfish has two pairs of antennae; insect has one pair of antennae. 4. Insects have three pairs of legs and one pair of antennae; as adults they breathe by means of tracheae; adults usually have wings, have one pair of compound eyes and usually three simple eyes. 5. Walking-stick resembles a twig; dead-leaf butterfly looks like a dry leaf; katydid looks like a green leaf; crayfish is colored like the mud and stones; many caterpillars are green, like the leaves upon which they feed. 6. Advantages: offers protection against cuts and blows; gives a large surface for muscle attachment. Disadvantages: is somewhat unwieldy and heavy, at least in the larger Crustacea; is not elastic and must be shed for growth to take place. 7. Complete metamorphosis consists of four stages: egg, larva, pupa, adult. Incomplete metamorphosis consists of three stages: egg, nymph, adult. 8. See Everyday Biology, pp. 200-202.

EXPERIMENT 53. Mosquito

The common mosquito (Culex) egg hatches in a day or less; it requires about a week to develop from the larval into the pupal stage and about another week to develop into an adult. Neither the larva nor the pupa can push the breathing tube through the oil film, or else the tube becomes clogged with oil, and the insect then dies for lack of oxygen.

PROJECT 11. Life Histories of Insects

The eggs will not hatch because they have not been fertilized.

EXPERIMENT 54. Fish

There are probably seven or eight fins, depending on whether the dorsal fin is single or double. It uses the pectoral and pelvic fins in stopping, and the tail and the caudal fin chiefly in swimming. It can remain in one place with only the slightest movement of fins. Pectoral and pelvic fins are in pairs. Those along the dorsal line aid in maintaining balance and may serve as protection. The scales overlap from front to back. The eyes are somewhat movable, but there are no eyelids. Having the eyes placed on the sides of the head enables the fish to see behind without turning around. There are usually four gills on each side (in some species there are five). The gill filaments are finely divided, thus providing a larger surface for the absorption of oxygen. The gill filaments point backward from the mouth. In this position they float free in the water current.

Questions for Study (pp. 204-211). 1. Streamlined body; fins; gills; overlapping scales; no projecting shoulders or appendages. 2. Homologous structures are those having the same general structure or originating from the same part of the body. The pectoral fins are homologous to the arms of man, and the pelvic fins to the legs. 3. Cod, halibut, tuna, salmon, herring, haddock.

EXPERIMENT 56. Frog

1. General Adaptations. The color varies from green to spotted. Such coloring is an advantage in that it resembles the vegetation or the spots of light and shade. The undersurface is lighter in color, thus appearing to an enemy below to be nearly the color of the sky. The frog floats with the tip of the head out and with legs hanging down. In this position it can see above

water and breathe, but cannot be seen. Yes, the bulging eyes enable it to see directly in front, also nearly directly behind. There are three eyelids on each eye. There are an upper and a lower lid and a third transparent eyelid which pulls up from below. Evidence that it can hear is its movement at a sharp noise. The tympanic membrane corresponds to the eardrum.

2. Locomotion. Jumping, walking, and swimming. (1) The hind legs are many times as long as the front legs. (2) Hind legs are used for jumping and swimming; front legs for support when resting and for walking. (3) Four toes on front feet; five toes on hind feet. (4) Only hind feet are webbed. The ankle and toes are longer than the bones from knee to ankle. This great length is an aid in jumping.

3. The Mouth. The frog uses its tongue to secure food, and sometimes the frog darts quickly forward after larger prey. The tongue is attached at the front of the mouth, with the free end lying backward. The large mouth enables the tongue to move freely. There are tiny teeth along the edge of the upper jaw, but none on the lower jaw. There are two large teeth in the roof of the mouth. The internal openings of the nostrils are on each side of these teeth. The glottis leads to the trachea. The opening near the angle of the jaw leads to the cavity back of the tympanic membrane. It serves to admit air to this cavity and thus equalize pressure on the two sides of the membrane.

4. Internal. The blood vessels in the skin may take in oxygen directly through the moist skin. The heart is farther anterior (under the shoulder girdle). The liver has three lobes. The gall bladder lies under one of the right lobes. The stomach lies largely on the left side. The intestine is slightly coiled. There are blood vessels in the mesentery. The spleen is not connected with any organ. The lungs lie under the body wall along each side. The fat bodies will be large in the fall, but very small in the spring after hibernation and mating. They store food.

5. Nervous System. The nerves from the spinal column go to the legs. They control the muscles which have to do with jumping. The membrane covering the brain contains small capillaries which bring food and oxygen to the brain. It also serves as a protective covering.

EXPERIMENT 57. Internal Structures of the Frog

1. The main trunk leading from the ventricle branches to right and left very near the heart. Each of these branches divides into three blood vessels. One goes to the head; the second arches around back of the heart and joins the corresponding vessel from the other branch, forming the dorsal aorta; the third goes to the lungs. (Refer any pupil who wishes to work on this problem to such an advanced text as Hegner's College Zoology.) 2. The female may contain vast quantities of eggs. If the animal was caught near the breeding season, the oviducts may be very large (they are white coiled structures). The male has small bean-shaped sperm glands located near the kidneys. 3. The hump in the frog's back is caused by the joining of the pelvic girdle to the spinal column.

Questions for Study (pp. 211-218). 1. Smooth-skinned chordates, usually having a complete metamorphosis and usually passing part of their lives under water. 2. Frog, toad, mud puppy, salamander, newt. 3. (1) Eggs laid in water. (2) Eggs hatch (eight to ten days). (3) Young tadpoles attach themselves by sucking disk; nourished by egg yolk. (4) Mouth develops, and tadpole swims about, hunting food; external gills develop. (5) Internal gills develop, and external gills disappear. (6) Tadpole increases in size; legs begin to develop. (7) Hind legs appear; tail becomes shorter; lungs developing. (8) Front legs appear; tadpole comes to the surface to breathe. (9) Tail is completely absorbed, and young frog hops out on land. 4. Toads and frogs eat insects; frog legs are used as food.

5.

	Mouth	Food	Organs of Respiration	Length of Intestine
Tadpole	Small, round	Algae, organic matter	Gills	Very long, coiled
Frog	Large	Insects, worms, etc.	Lungs	Short, slightly coiled

Questions for Study. Reptiles (pp. 218-225). 1. Are covered with scales, breathe by lungs, have no metamorphosis. 2. Answers will include a variety of snakes, turtles, etc., differing with the locality. 3. Snakes are valuable destroyers of insect and rodent pests; most of them are not poisonous and do not harm man in any way; most of them are truly timid creatures. 4. The hard shell, the horny beak.

EXPERIMENT 58. The Bird

The wing and tail feathers are long and are supported by a stiff quill. Most of the other feathers (contour feathers) are shorter and have a more pliable quill. There are also the fine down feathers next to the skin. The wings are long, jointed, and capable of moving freely. The wings move backward and downward at the same time, and then forward in a sort of figure 8. The tail is used for balancing and steering. There are usually four toes. Most birds have three toes in front and one behind. The shape of the beak varies with the species of bird. Most birds take a little water into the beak and tip the head back to let it run down the throat. Pigeons and doves drink with the beak immersed. The eyes are very similar to those of man. The third eyelid is attached at the lower inside corner of the eye. The nostril openings are at the base of the beak or perhaps on the beak.

EXPERIMENT 60. Feather Structure

The fine filaments (barbs) which make up the feather branch into still finer filaments (barbules) which overlap one another. These possess many tiny hooks which catch on neighboring hooks and hold to make the smooth feather surface.

EXPERIMENT 61. Perching

The tendons from muscles in the bird's toes pass behind the ankle joint. The farther this joint bends, the tighter it draws the tendons and curls up the toes.

Questions for Study (pp. 225-231). 1. Fossil evidence of an animal having feathers and wings but lizardlike tail and head. Modern birds have scaly legs and feet. 2. Feathers, wings, hollow bones, and air sacs. 3. Such examples as the heron and the crane, which have long legs that fit them for wading to catch their food; buzzards, which have very long wings that enable them to take the best advantage of air currents in soaring; woodpeckers, which have spine-tipped tail feathers that aid in supporting the bird on a tree trunk. 4. They migrate south to reach a region where food is available or to escape cold weather. They migrate north to find more room for breeding or as a result of an instinct surviving from glacial ages or because of the internal stimulus supplied by developing reproductive cells. (The class probably will not give this last point.) 5. Cats, snakes, squirrels, weasels, hawks, owls, man.

Questions for Study (pp. 231-242). 1. They are more or less covered with hair; the young are born alive and are fed with milk from mammary glands; they breathe by lungs; they have no metamorphosis. 2. Wings of a bat; flippers of a seal; long, hoofed legs of running animals; clawed feet of beasts of prey; digging foot of mole; hands of monkeys. 3. Horns of deer, bison, or rhinoceros; hoofs of zebra or horse; teeth of dog; trunk and tusks of elephant; claws of lion. 4. Rodentia: rat, rabbit, beaver (gnawing teeth). Carnivora: dog, lion, tiger (tearing teeth, clawed feet). Ungulata: horse, cow, sheep (hoofs, teeth for eating grass). Primates: gorilla, monkey, man (walk upright, use hands). Ungulata are most important. They furnish meat, milk, leather, beasts of burden, etc. Rodentia damage field crops, trees, stored goods, etc. 5. The animals listed that are not mammals are salmon, robin, Gila monster, rattlesnake. The herbivorous mammals are elephant, horse, giraffe, cow, sheep, deer. Carnivorous are lion and seal. Omnivorous are man and rat.

EXPERIMENT 62. Bone Structure

There is a thin membrane (the periosteum) covering the bone. At a joint the bones are held together by ligaments. The joint surfaces are very smooth, enabling the bones to move over each other with little friction.

EXPERIMENT 63. Joints

The joints in the skull are immovable joints, where the bones are dovetailed together. The hip joint will move somewhat in all directions; the knee joint bends backward only; the ankle joint moves somewhat in all directions.

EXPERIMENT 64. Composition of Bones

After the mineral matter is removed, the bone bends easily. One function of the animal matter is to enable bones to bend slightly without breaking. When the animal matter is removed, the bone will not bend at all and may snap readily. The mineral matter gives hardness to the bone.

Human Skeleton. The bone (femur) from the hip to the knee is the longest. The skull, the chest, and the pelvis are boxlike. The bones of the arms and of the legs are levers. The backbone is made up of smaller bones, or vertebrae. The skull is composed of bones immovably joined together.

Exercise on Biological Principles, pp. 97-98. 1. (Answers will of course vary widely.) The earthworm has no special organs of locomotion but moves by contraction of body muscles, while a bird possesses both wings and legs. The worm has only a mouth for getting food, while a lion uses its claws and its sharp teeth to aid in catching prey. 2. Such examples as the deer, which lives in the plain country and has long legs that aid it in escaping from enemies; the mole, which has feet modified for digging in the soil; the bat, which has front limbs modified to form wings.

Questions for Study (pp. 246-256). 1. For anchorage, for water, for minerals. Plants add organic matter to the soil when they die and decay; leguminous plants add nitrogen compounds. 2. Bacteria of decay change the organic material of dead plant and animal bodies into compounds that can be used by plants; nitrogen-fixing bacteria change free nitrogen into nitrogen compounds; other bacteria (nitrifying bacteria) change certain nitrogen compounds into nitrates that can be used by plants. 3. The nitrogen-fixing bacteria which grow on the roots of legumes make the soil richer in nitrogen compounds which all plants need. 4. Erosion removes the top fertile soil, leaches out soluble minerals, and causes gullies. 5. Wind may cause erosion when the soil is loosened by constant plowing, when rainfall is insufficient, and when cover crops are inadequate. 6. See Everyday Biology, pp. 253-254. 7. Erosion of farm land reduces crop production; prices of crops are therefore higher, and city people find the cost of living higher.

EXPERIMENT 65. The Nitrogen Cycle

There are nodules (containing nitrogen-fixing bacteria) on the roots of leguminous plants but not on other plants.

The pupils will probably show the sheep dead and decaying, or fecal matter decaying, as the next step, with the label "Action of decay bacteria." Then follows a step showing other soil bacteria reducing the products of decay to nitrogen compounds and nitrates. A line from this step to the plant roots indicates that the nitrogen compounds are used by the plant.

Some pupils may add another cycle by drawing nodules on the roots of the clover plant, with an arrow, extending from the surrounding air, labeled "Free nitrogen."

Questions for Study (pp. 256-269).

Name of Pest	Its Host or Hosts	Means of Fighting It
Potato beetle	Potato plants	Poison sprays
Fruit fly	Oranges, grapefruit, tomatoes, etc.	Quarantine, destruction of infested materials, poison sprays
San José scale	Fruit trees	Contact sprays (such as oil)
Wheat rust	Wheat and barberry	Elimination of the alternate host
Cottony-cushion scale	Orange tree	Introduction of the Australian ladybug
Cotton-boll weevil	Cotton	Rotation of crops
Codling moth	Apple tree	Poison sprays
Texas cattle fever	Cattle and tick	Dipping cattle, developing resistant strains of cattle

Name of Pest	Its Host or Hosts	Means of Fighting It
Animal lice	Chickens, hogs, etc.	Dusting with poison, dipping, disinfecting quarters
Hog cholera	Hogs	Quarantine, inoculations
Potato wart	Potato tuber	Destroying diseased potatoes, crop rotation

Questions for Study (pp. 270-280). 1. They furnish such products as lumber, turpentine, etc.; they prevent erosion, regulate the rate at which water runs off, and so help to prevent floods; they furnish homes for many kinds of wild life. 2. Forest conservation means the wise use and care of forests so that they may continue to produce crops of trees. 3. Man cuts over land to free it for farming, cuts trees for use, sometimes burns over forest land, or sets fires carelessly. Fires injure forests by destroying large trees, by killing young seedlings, by burning the humus from the soil and hence leaving it infertile. Insects defoliate trees or tunnel in the wood. Fungi injure trees by attacking the leaves or other living parts or by destroying the wood. 4. Some varieties are very scarce, and picking may exterminate them. Many plants have leaves so arranged that they are picked along with the flowers, thus hindering photosynthesis. Some are easily pulled up by the roots. A few grow only from seeds, not from a bulb or a rootstock, so that if the flowers are destroyed they have no means of reproduction.

Questions for Study (pp. 280-286). 1. By eating insects: wrens, woodpeckers, warblers, orioles. By eating weed seeds: sparrows, quail, finches, blackbirds. By eating rodents: owls, hawks. By acting as scavengers: sea gulls, vultures. 2. Man has hunted some species too ruthlessly; natural habitats, such as swamps and forests, have disappeared; parasites have killed them. 3. Game and nongame birds are defined; nongame birds cannot be killed, nor their eggs collected; short open-hunting seasons are provided for game birds; insect-eating birds are protected at all times; migratory birds are protected by a treaty between Canada and the United States; bird sanctuaries have been established.

Questions for Study (pp. 286-294). 1. If not protected, they may become extinct; some are valuable for food or for furs; some are valuable as insect-eaters or destroyers of other pests. 2. This answer will vary with the locality. 3. Laws which limit the size and the numbers of fish that can be taken, which provide short fishing seasons, which prohibit use of dynamite etc., which provide for the artificial propagation of fish and the restocking of streams. 4. Oysters, by artificial propagation and cultivation; clams, by closed seasons, by regulating the size that can be taken, and by restocking of barren waters; lobsters, by artificial propagation and by laws regulating the size that can be taken.

Questions for Study. National Parks (pp. 294-299). 1. To preserve unusual natural features, to provide game refuges, to provide recreation grounds. 2. Hundreds of problems could be suggested, such as the following: to study the feeding habits of certain animals found in the park; to classify the plants found; to study the reasons for the increase or decrease in numbers of some plant or animal; to study the habits of one animal (as was done for the Rocky Mountain sheep in the text); to study the plants and animals found in different elevations or in different kinds of territory. 3. Reforestation and other forest work; soil conservation and flood control; conservation of wild life; development of parks and other recreational facilities.

Questions for Study (pp. 302-313). 1. Most green plants are able to make all their own food. Some, like mistletoe, take some food from a host plant. Others, like pitcher plants, supplement their food-making by capturing insects. Saprophytes obtain food from nonliving organic matter. Parasites live on living organisms. 2. Amoeba: no special structures; any part of body may serve as mouth. Paramecium: oral groove, mouth. Sponge: pores to admit water. Hydra: tentacles, stinging cells, crude mouth. Earthworm: mouth. Snail: mouth, tongue covered with teeth. Crayfish: pincers, complex mouth parts. Insects: chewing mouth parts, as in grasshopper; piercing-sucking mouth parts, as in mosquito; coiled sucking mouth, as in butterfly; sponging mouth parts, as in house fly. Fish: mouth, sometimes teeth. Frog: tongue, teeth. Reptile: large mouth, teeth. Bird: beak; feet and wings to aid. Mammal: teeth, feet, etc.

Questions for Study (pp. 313-317). 1. Energy foods: protein, carbohydrate, fat. Non-energy foods (essential): water, minerals, vitamins. Non-energy foods (nonessential): stimulants, flavors. 2. Supply building material; serve as the source of energy; supply substances which promote health. 3. Heat energy, energy of movement, potential energy of stored food.

EXPERIMENT 66. Food Tests

1. Starch turns blue or purple when iodine is added.

2. The contents of the tube containing sugar become yellow or brick red (depending on the amount of sugar present).

3. The protein becomes yellow when nitric acid is added. The addition of ammonium hydroxide turns it bright orange.

4. Fat causes translucent spots on paper.

Questions for Study. Foods (pp. 317-335). 1. Protein contains nitrogen in addition to carbon, hydrogen, and oxygen. 2. Carbohydrates, as sugar, rice, potatoes and cereals furnish energy; fats, as butter, cream, bacon, and nuts, furnish energy; proteins, as lean meat, eggs, cheese, and dried beans, furnish building materials as well as energy. 3. It contains all the essential food elements; it contains considerable calcium, valuable in bone-building. 4. Milk, leafy vegetables, eggs, prunes, raisins. 5. To supply that needed by the protoplasm; for transportation; to dissolve or soften food. 6. They make food more appetizing. 7. They supply no food meterial; their use may cause one to omit valuable food, as milk; the stimulation they give may prove detrimental to young persons.

EXPERIMENT 69. Digestion in Seeds

The tests will probably show starch in all seeds and sugar in those only that have begun to germinate, thus showing that digestion takes place in germinating seeds.

EXPERIMENT 70. Digestion in Plants

The tube with starch and diastase will test for sugar, showing that diastase digests starch. It may also give the starch test, if digestion has not been complete. The control tests for starch but not for sugar.

Questions for Study (pp. 336-343). 1. Enzymes are produced by living things only. 2. Because the cell cannot take food into itself. 3. Sponge, Hydra, flatworm. 4. Digestion of food by enzymes secreted by cells of inner layer. Water continually circulates through the cavity in the sponge, and food would not stay there to be digested. 5. Flatworm: mouth, intestine. Earthworm: mouth, crop, gizzard, intestine. Crayfish: mouth parts, mouth, stomach, intestine, liver (hepatopancreas). Frog: mouth, stomach, small intestine, large intestine, pancreas, liver. Man: same as frog.

Exercise on Biological Principles. A simple many-celled animal like the hydra has only a cavity in which digestion occurs; a complex animal like a frog has a mouth, stomach, intestine, liver, and pancreas.

EXPERIMENT 71. Digestion in the Mouth

The cornstarch becomes sweeter in the mouth. Tube 1 tests for sugar; tube 2 does not test for sugar.

EXPERIMENT 72. Digestion in the Stomach

A combination of water, pepsin, and hydrochloric acid is most effective in digesting protein.

EXPERIMENT 73. Digestion in the Small Intestine

1. A mixture of water and some alkali is most effective in making fat into an emulsion. 2. Pancreatic juice acts on fat, protein, and starch. (If possible, keep the test tubes for two or three days, until the effect of the pancreatic juice on the solid foods is quite apparent. Pupils will be forcibly impressed with the meaning of digestion as they see the contents of the tube become entirely clear.)

Questions for Study (pp. 343-354). 1. Mouth: to receive and chew food, to digest starch. Pharynx: no change in food. Esophagus: no change in food. Stomach: to store food, to digest protein, to soften food, to kill bacteria. Small intestine: to complete digestion of starch, protein, and fat; to absorb food. Large intestine: to absorb water, to store food wastes. 2. Salivary: mouth; ptyalin; digests starch. Gastric: stomach; pepsin, rennin; digest proteins. Pancreas: small intestine; trypsin, amylase, lipase; digest proteins, starch, fat. Liver: small intestine; bile; aids digestion of fat. Intestinal: small intestine; erepsin, maltase, etc.; digest proteins and carbohydrates. 3. In the mouth the food is broken into small pieces, and some of the starch in the potatoes is changed to sugar. In the stomach the protein in the meat is broken up by the enzymes in the gastric juice. The liquefied food passes on into the small intestine. Here pancreatic juice and bile are poured on the food.

The bile and the pancreatic juice digest the fats; the pancreatic juice digests proteins and carbohydrates. The intestinal juice completes the digestion of any foods that have not been entirely reduced.

EXPERIMENT 74. Plant Circulation

The red ink rises in the fibrovascular bundles, and evidence of it will be seen even in small veins in the leaves.

Exercise on Scientific Method. The roots form only above the cut. Food is carried downward in the phloem tubes in the bark; that part of the stem below the cut does not receive food. The roots therefore appear only on that part of the stem which is receiving food and is growing.

EXPERIMENT 75. Circulation in the Earthworm

The blood flows toward the head in the dorsal blood vessel. Thence it flows into the five pairs of hearts (these are probably beating more slowly than does the heart of man). The earthworm has red blood. (The hemoglobin is in the plasma instead of in corpuscles.)

Questions for Study (pp. 355-365). 1. Many of their cells are too far from the supplies of food and oxygen. 2. Carry food and oxygen to cells, remove wastes, supply needed liquid, distribute heat, carry hormones. 3. Liquids rise in the xylem and descend in the phloem. 4. In a higher plant it is made up of a series of cells or tubes, placed end to end, each separated by a membrane. In a higher animal it is a single continuous series of tubes. 5. An open vascular system consists of tubes which carry blood from the heart, but no tubes to return it. A closed system has continuous tubes to carry blood from the heart and to return it.

Exercise on a Biological Principle. The fish has a two-chambered heart, the frog a three-chambered heart, and the mammal a four-chambered heart. (Many answers will differ from this in some respects.)

EXPERIMENT 76. Circulation in the Frog

The corpuscles move rather rapidly through the capillaries, but more slowly than in the larger blood vessels. This slowing up of the blood stream enables the red corpuscles more readily to give up their load of oxygen and to take in carbon dioxide.

EXPERIMENT 77. Circulation in Man

The heartbeat, the pulse at the wrist, and the pulse in the temple will be very nearly the same. There is no pulse in veins. The blood in the veins in the hand is flowing upward, back to the heart. The valves aid in keeping the blood moving upward, against gravity.

Questions for Study (pp. 365-371). 1. If they were like veins, the arteries would not have sufficiently muscular walls to aid in forcing the blood along. 2. The single layer of cells permits food and oxygen to pass out into the tissue spaces. 3. Similarities: Both contain liquid; white corpuscles may be found in both; both may carry wastes from the cells. Differences: The circulatory system consists of a complete system of blood vessels beginning and ending at the heart; the lymphatic system consists only of tubes going from tissue spaces in all parts of the body toward veins in the neck. Only the circulatory system carries red corpuscles, food, and oxygen. The lymphatic system is equipped with numerous glands; no similar structures are found in the circulatory system. Circulation in the circulatory system is maintained by the heart; circulation in the lymphatic system is maintained by muscular movements of the whole body. 4. From the left ventricle to the large artery (aorta) which sends branches to all parts of the body; through the capillaries of the body to the veins, which unite to form large veins returning to the right auricle; then to the right ventricle; through the pulmonary arteries to the lungs; back through the pulmonary veins to the left auricle; then to the left ventricle. 5. Pulmonary artery; pulmonary vein. 6. Pulmonary artery; pulmonary vein. 7. Alcohol at first stimulates circulation, then slows it up. The increased circulation of blood in the skin may result in loss of too much heat.

EXPERIMENT 78. Structure of the Heart

There are four cavities in the heart. The walls of the ventricles are thickest. All the chambers have connecting blood vessels. One can usually find the pocketlike valves between auricle and ventricle.

EXPERIMENT 79. Blood

The blood is yellowish when seen through the microscope. The plasma is colorless, as are the white cells. The white corpuscles are larger than the red and without as definite shape. (They usually look rather bluish, as compared to the yellow color of the red corpuscles under the microscope.) The human blood is composed of a clear, uncolored (or very slightly yellowish) liquid and corpuscles.

Questions for Study (pp. 372-379). 1. Red corpuscles are made in the spongy marrow of the bones. 2. White corpuscles are made in the lymph glands, liver, spleen, and marrow of bones. 3. Plasma: to carry corpuscles, food, etc. Red corpuscles: to carry oxygen and carbon dioxide. White corpuscles: to destroy germs. Blood plates: to aid in clotting. Fibrinogen: to aid in clotting. 4. Mucous gland: to secrete mucus, a fluid which moistens the walls of the intestine. Capillary: to absorb digested proteins and carbohydrates. Lacteal: to absorb digested fats. Artery: to bring blood to the villus. Vein: to carry blood from the villus. 5. Lungs: oxygen taken in by red corpuscles; carbon dioxide given off by the blood. Villi: digested food taken into the blood; some oxygen removed and carbon dioxide added. Liver: surplus sugar taken out; worn-out red corpuscles removed; some oxygen removed and carbon dioxide added. Brain: food and oxygen removed; carbon dioxide, water, and other wastes added.

EXPERIMENT 80. Respiration in Plants

Pupils will probably write "Carbon dioxide" in the first jar and "No carbon dioxide" in the second jar. They will probably also write "White coating" or

"White scum," with a line leading to the surface of the limewater in the first jar, and "No white coating" similarly in the second jar. They will label the bean plants "Experimental factor" and the second jar "Control."

The green plant gives off carbon dioxide, as is shown by the fact that the limewater becomes cloudy or covered with a scum.

EXPERIMENT 81. Respiration in Seeds

The seeds grow better in the open jar.

Exercise on Scientific Method. 1. The open jar was the control. It served to show that the results observed in the first jar were due to the exclusion of oxygen. 2. The experimental factor was oxygen, since it was the one factor that differed in the two jars. 3. Some seeds in the closed jars may grow, because there was air in the jar before it was sealed. 4. Put into the jar to be sealed a bottle cap in which is a little red phosphorus. Ignite the phosphorus by touching it with the heated end of a file or nail, then immediately seal the jar. Now put into the bottle to be left open another bottle cap with red phosphorus. Ignite it and cover it while the phosphorus is uniting with the oxygen. Then open the jar and remove the cap with whatever red phosphorus remains. Air containing oxygen will enter this jar. There will be in each jar a powder formed by combining phosphorus and oxygen; that is, all factors will be the same in both except that one will contain oxygen while the other will not. 5. Choose two similar jars. Into one put a number of seeds that have been soaked; into the other put an equal number of dry seeds. In each jar place a small dish of limewater. Cover each jar loosely to prevent too rapid evaporation.

Questions for Study (pp. 380-383). 1.

	Photosynthesis	Respiration
Gas used?	Carbon dioxide	Oxygen
Gas given off?	Oxygen	Carbon dioxide
Occurs in what cells?	Green (chlorophyll-bearing)	Any living
Time of day?	Sunlight hours	All the time
Waste products?	Oxygen	Carbon dioxide and water
Relation to energy?	Energy stored	Energy released
Relation to food?	Food built up	Food used

2. Thallophyta: none. Bryophyta: stomata in some. Pteridophyta: stomata. Spermatophyta: stomata, lenticels. 3. Carbon dioxide and water. 4. Internal respiration is the exchange of oxygen and carbon dioxide through the walls of living cells; external respiration is the process of taking oxygen into the blood and giving off carbon dioxide from the blood, in the lungs, gills, or skin. 5. Stomata, in epidermis of leaves; lenticels, in the bark.

EXPERIMENT 82. Breathing

When the volume of the lung cavity is increased, the greater air pressure outside pushes air into the lungs. When the volume of the lung cavity is decreased, the greater air pressure inside pushes air from the lungs.

Questions for Study (pp. 384-393). 1. Amoeba: none. Sponge: none. Starfish: filaments of protoplasm; all over body. Clam: gills; two on each side under the shell. Crayfish: gills; under the carapace, attached to the legs. Fish: gills; at sides of head, under gill covers. Earthworm: skin; all over body. Grasshopper: tracheae; throughout body. Frog: saclike lungs; each side of body. Man: spongy lungs; chest cavity. 2. Pharynx: air warmed. Trachea: dust removed by cilia; air warmed. Bronchi: dust removed. Bronchial tubes: no change. Air sacs (alveoli): oxygen taken into blood; carbon dioxide given off by it. Bronchial tubes, bronchi, trachea, pharynx, nasal passages: no change in air passing out.

EXPERIMENT 83. The Kidney

The pupils will be able to see the central cavity of the kidney and the two divisions (cortex and medulla) of the fleshy part.

Questions for Study (pp. 394-398). 1. In every living cell. 2. Carbon dioxide, water, nitrogenous wastes. 3. One-celled plants: none. Higher plants: in leaves that are shed, pits, pith cells. Protozoa: through cell wall. Simple Metazoa: through mouth or through cell walls. Higher animals: large intestine. 4. Amoeba: one contractile vacuole. Paramecium: two contractile vacuoles. Earthworm: excretory tubules (nephridia). Bee: Malpighian tubes. Clam: simple kidney, bladder. Fish: kidneys, bladder. Dog: kidneys, bladder. 5. Contractile vacuole. 6. The individual cells in higher animals are too far from the outside to get rid of wastes individually.

Questions for Study (pp. 398-401). 1. Gives off urea; excretes worn-out red corpuscles. 2. Any living cell, but especially those of the liver, can change nitrogenous wastes to urea. The liver also breaks up red blood cells and gives off as wastes all but the iron. 3. (1) Kidney: urea, mineral salts, water; (2) Lungs: carbon dioxide, water; (3) Skin: water, mineral salts; (4) Liver: nitrogenous compounds. 4. (1) To pour moisture on the skin, which cools the skin by evaporation; (2) to remove excess water and salts from the body. 5. Liver: to manufacture bile and store sugar. Lungs: to take oxygen into the body. Sweat glands: to regulate body temperature.

Questions for Study. Glands (pp. 402-410). 1. Duct glands pour their secretions through tubes; ductless glands have no tubes, but pour their secretions directly into the blood. 2. Duct glands. They pour their secretions out through the mouths of the glands, and not into the blood. 3. Chordata. 4. Thyroid: regulates rate of metabolism of food; influences physical and mental development. Parathyroid: regulates calcium metabolism. Pituitary: controls growth of bones; regulates activity of nerve cells, muscles, kidneys. Adrenal: influences the amount of sugar supplied to the blood, and thus influences the energy supply available. Causes more rapid heartbeat; contracts muscles in blood vessels. Pancreas (islands of Langerhans): controls amount of sugar in blood, and amount available for the cells to use. Reproductive: causes secondary sexual characters. 5. Pituitary; pituitary; thyroid. 6. Pineal. 7. Adrenal. 8. Pancreas: to produce digestive enzymes; to produce the hormone insulin. Reproductive glands: to produce reproductive cells; to produce hormones which determine secondary sexual characters. Glands of small intestine: to produce certain secretions in the intestine; to produce the hormone secretin. 9. Pancreas. 10. Thyroid.

Exercise on Scientific Attitudes and Scientific Methods. Attitudes 1, 2, 6, 7, 9. The Elements of Scientific Method were probably all used.

EXPERIMENT 84. Tropisms in Plants

The roots grow downward and the stems upward, no matter in what position the garden is placed.

EXPERIMENT 85. Tropisms in Animals

The reactions to light will of course vary with the animals available for use. Millepedes, ground beetles, and most spiders will react negatively.

Exercise on Scientific Method. 1. One would not be justified in concluding that all similar animals would react as these did, because conclusions cannot be drawn from a few observations. 2. (1) Place a jar containing a protozoan culture in such a position that one side is light and the other shaded. (2) Put earthworms on moist soil. Turn a flash light upon them and watch their reactions. (3) Put some flies in a jar or bottle and cover it. Turn one end of the bottle toward the light. After a minute, turn the bottle around and note the reaction of the flies.

Questions for Study (pp. 414-418). 1. The response of an organism to a stimulus is a reaction. 2. A sudden loud noise makes a baby cry; a dog will jump and bark for a piece of meat held high in the air. (The examples given will of course vary widely.) 3. All organisms respond to gravity, contact, water, heat, light in general. Higher plants respond to sunlight. No (all plants do not respond to any to which all animals do not). No. Higher animals respond to sound, other organisms like themselves, odors, flavors. 4. A tropism is a simple reaction which is unlearned, automatic, and fixed.

Exercise on Biological Principles. 1. The sun is shining hot on the beach. The turtles crawl upon a rock or a log to sun themselves, the dog hunts a shady spot, the girl puts up a beach umbrella, other people bathe. 2. In general, tropisms tend to bring the organism to a more favorable environment and away from unfavorable factors. For example, the response of roots to water enables the plant to secure the water necessary to life. The turning of leaves toward the sun aids in photosynthesis. (The class will give many similar illustrations.)

Questions for Study (pp. 419-425). 1. Similarities: Both are made up of protoplasm, and both carry on the same life functions. Differences: A neuron has branches, one of which may be very long; their functions are different. 2. It has a more complex nervous system and a central nerve cord. 3. They are inherited, unlearned, and relatively fixed. They differ merely in degree. 4. It was an instinctive action. 5. The ability of a dog to swim; a silkworm spinning a cocoon; etc.

Questions for Study (pp. 425-430). 1. The nerve cord of an invertebrate lies along the ventral side of the body cavity; in a chordate it lies along the dorsal side of the body. 2. Some of the end organs of pain in the foot are stimulated by contact with the stone. The impulse passes over a sensory neuron to the spinal cord. Here contact is made with dendrites of a motor neuron, and a message is carried to muscles of the leg over the motor neuron. As a result the muscles move the foot. The sensory and motor neurons form a reflex arc. 3. Hydra: nerve net. Starfish: nerve ring, branching nerves. Earthworm: ventral nerve cord, ganglia, "brain." Insect: ventral nerve cord, ganglia, brain. Frog: dorsal nerve cord, brain. Man: dorsal nerve cord, brain. 4. Cerebellum: coordinates muscular activity. Medulla: controls such involuntary movements as heartbeat and breathing. Spinal cord: controls reflex actions. Nerves: sensory nerves carry impressions to the brain; motor nerves carry messages from the brain to a muscle. Sympathetic nervous system: controls activities concerned with digestion, excretion, etc.

Exercise on a Scientific Principle. "The larger the cerebrum the more intelligent the animal." (The wording will of course differ as the pupils state the principle.)

Questions for Study (pp. 431-440). 1. An unlearned response is inherited and fixed; a learned response is acquired and depends on experience. 2. A dog can learn not to run and bark at passing cars; birds learn not to fear man; etc. 3. Learned responses result from experience through trial and error; consist of modifications of inherited responses; are not fixed, but depend on pleasure and annoyance, and involve choice. 4. Lift the dog's foot, at the same time saying "Shake hands." Then put the foot down and reward the dog with a bit of food or a pat. Do this same thing over and over until he will lift his paw when you say "Shake hands."

Questions for Study (pp. 440-450). 1. First you must desire to learn to use the typewriter; next secure expert directions in learning the correct methods; practice these attentively, being careful not to deviate from correct practice; finally the correct reactions will become habitual, that is, the cerebrum no longer needs to be concerned with the reactions because these are taken over by lower centers. 2. Almost any person who wants to learn French should be able to do so. Age has less to do with learning than have willingness to study and to practice speaking, and a desire to succeed. 3. In general, superiority in one respect goes with superiority in other respects. Thorndike states this principle thus: "Correlation and not compensation is the rule." 4. The young can learn from the parents; the young are more mature physically and mentally by the time they face the world alone; the young are more likely to survive if cared for until they are fairly well grown.

EXPERIMENT 87. Nerve Endings

The nerve ends of touch are closest together on the finger tips and the tip of the tongue. They are farthest apart on the shoulders and back.

By reproducing identical conditions with different people each serves as a control by making sure that no unusual results are accepted as conclusions.

EXPERIMENT 88. Sense of Taste

If the subject can tell the apple, the onion, and the potato apart, it is by feeling. Most people cannot distinguish the three sirups suggested. It is the difference in smell rather than in taste which enables us to distinguish them.

Questions for Study (pp. 451-456). 1. They have no sense organs and fewer end organs. 2. Sense organs on the head enable the animal to see, smell, hear, and perhaps feel out his environment before he actually enters it. 3. Earthworm: taste, touch; touch. Crayfish: smell or taste, sight; sight, touch. Bee: smell, sight; sight, touch. Fish: sight, smell or taste; sight. Frog: sight; sight, hearing. Bird: sight, taste; sight, hearing. Dog: smell, sight; sight, hearing, smell.

EXPERIMENT 89. The Structure of the Eye

The optic nerve is white. The outer coat of the eye is not easily pierced. This is of advantage in protecting the inner parts from injury. The image seen through the eye is upside down. The liquid in the eye is transparent. The retina is dark blue, almost black.

Exercise on Scientific Attitudes, p. 149. Especially numbers 3, 5, 6, 7, 8, 9, and 13.

Exercise on a Biological Principle, p.150. The deer, with keen senses of smell, hearing, and sight, readily becomes aware of an enemy. A lion tracks its prey by the aid of its special senses.

Questions for Study (pp. 456-467). 1. Scattered nerve ends: earthworm; sensitive to light. Eye spots: Euglena; sensitive to light. Simple eyes: spider; distinguish size and movement. Compound eyes: insect; distinguish direction of light and moving objects and probably can judge short distances. Lens type: man; form true images. 2. One can judge distances if the eyes are on the same plane, or can see farther to the rear if the eyes are on the sides of the head. 3. Pupil: admits light to the eye. Iris: regulates the size of the pupil. Lens: focuses light rays on the retina. Cornea: admits light while protecting parts beneath. Liquids (aqueous and vitreous humor): hold eyeball in shape. Retina: contains nerve endings sensitive to light. Optic nerve: carries impulses to the brain. 4. The impulses received by the nerve endings in the eye are useless until they are interpreted by the brain. 5. The dog. The hearing organ of the grasshopper (locust) is on the abdomen, not the head. 6. Outer ear: to catch and focus sound waves. Canal: to carry sound waves inward. Eardrum: to vibrate in response to sound waves. Bones of middle ear: to carry vibrations across middle ear. Cochlea: contains nerve endings sensitive to vibrations. Auditory nerve: carries impulses to the brain. Semicircular canals: to aid in maintaining balance. Eustachian tube: to admit air to the middle ear and thus equalize pressure on the eardrum. 7. The sound waves which affect the nerve endings in the ear are not heard until the brain interprets them. (If pupils find this idea difficult remind them that an ear not connected with the brain might receive sound waves, but it would hear nothing.)

EXPERIMENT 90. Bacteria in Milk

(Experiments 90 and 91 may be started the same day, since each will have to stand for three or more days.)

Questions for Study (pp. 470-481). 1. Bacteria, Protozoa, molds, yeasts, rusts, smuts. 2. Diseases of two kinds: communicable, such as measles, scarlet fever, typhoid, etc.; noncommunicable, such as diabetes, heart disease, anemia, etc. How communicable diseases are spread by people: through contact with the sick, through material coughed or spit out or from droplets emitted in speaking, through excreta, through carriers, through handling articles handled by the sick. How communicable diseases are spread by animals: as victims of the disease, as hosts of the disease parasite, as carriers of insect parasites, as mechanical carriers. How communicable diseases are spread through water: through excreta which get into drinking water. How communicable diseases are spread through food: through milk contaminated by contact with those ill, through milk from tuberculous cows, through food exposed to flies, dirt, etc. 3. They may inherit a physical constitution susceptible to the disease, (though there is some scientific evidence that no such weakness is inherited); they may be exposed in very early life. 4. Through the nose or mouth in air breathed; through the digestive tract, from contaminated food or water; through breaks in the skin. 5. By destroying bacteria, by sterilizing wounds and scratches, by observing rules of cleanliness and sanitation, by quarantining.

Questions for Study (pp. 482-490). 1. Natural immunity: that resistance to a disease which one is born with. Due to (1) body structures, such as (a) skin, (b) hairs and cilia of respiratory tract, (c) white corpuscles, (d) body cells; (2) secretions, such as (a) saliva, (b) mucus of the nasal passages, (c) hydrochloric acid of the gastric juice, (d) tears; (3) individual characteristics, such as (a) kind of animal, (b) race, (c) family, (d) age, (e) physical condition. Acquired immunity: that immunity which one may secure during his life. Due to (1) having the disease, (2) having inoculations (a) with toxins, (b) with antitoxins, (c) with weakened or dead germs. 2. One should secure adequate sleep and rest, proper food, fresh air, sunshine, exercise. One should avoid becoming over-fatigued, living in badly ventilated, crowded rooms, and eating poorly balanced meals. 3. Antibodies formed during the first attack remain in the blood and combat any germs of that disease which may later enter the body. 4. The child may go through life without contracting the disease. Many common childhood diseases leave permanent ill effects. Many children's diseases are more serious early in life than later.

Questions for Study (pp. 492-509). 1. Diphtheria, scarlet fever, smallpox, tuberculosis, typhoid fever, malaria, yellow fever. 2. Successfully combated by means of inoculations: diphtheria, smallpox, typhoid fever; by eliminating animal carriers: malaria, yellow fever; by means of rest, etc.: tuberculosis. 3. By inoculation with antitoxins: diphtheria, tetanus, rabies; with dead bacteria: typhoid fever, smallpox; with weakened toxins: diphtheria; with toxin-antitoxin: diphtheria. 4. By sanitation, quarantine, better care of patients, knowledge of the nature of the diseases, use of inoculations in many diseases, use of many methods of prevention. 5. A toxin stimulates the body cells to manufacture antitoxin, which is active in combating the toxin. An antitoxin serves to combat the toxin, without any activity on the part of the body cells. 6. Before (rarely does a physician vaccinate one after one has developed symptoms of a disease). Because in vaccination weakened or dead germs are introduced into the body to stimulate the cells to make antibodies. If the person had the disease, the cells would already be making antibodies. 7. Malaria, African sleeping sickness, tropical dysentery, amoebic dysentery, Texas fever. 8. It destroys red blood cells and produces chills and fever. 9. No. The disease is carried only by mosquitoes of certain kinds. 10. Prevent multiplication of mosquitoes by destroying breeding places or by putting oil on standing water.

Questions for Study (pp. 510-515). 1. Taking daily exercise; resting before meals and perhaps immediately after meals; avoid fear, worry, anger, etc. at mealtimes; establishing regular habits of elimination. 2. One is very likely to be subsisting on a poorly balanced diet, which may eventually be harmful. One may eat too little for health. The resistance of the body may be lowered to a point where one succumbs to diseases readily. 3. Alcohol hinders the digestive processes, harms the linings of the digestive organs, and reduces the amounts of digestive juices produced. 4. The use of tobacco may cause poor appetite, nausea, bad tastes in the mouth, and perhaps indigestion.

Questions for Study (pp. 515-518). 1. Brush the teeth regularly and carefully; have the teeth examined by the dentist every six months; have crowded or uneven teeth straightened; do not depend on mouth washes or dentifrices for cleaning the teeth. 2. The temporary teeth should be cared for that they may be retained until permanent teeth are ready to appear. Otherwise the shape of the jaw may be impaired. Such care also insures that the six-year molars are not neglected. Any necessary straightening of the teeth is more easily done when one is young and is more likely to result in symmetrical development of the jaw. X-rays will show missing, extra, or misplaced teeth, which the dentist can then care for before they cause trouble.

Questions for Study (pp. 518-526). 1. The athlete who smokes is generally less successful than the nonsmoker. Smoking may result in harm to respiratory organs. Smokers are more liable to respiratory infections than are nonsmokers. 2. Primarily to promote comfort by reducing the quantity of water vapor near the body; also to remove odors from the room.

Questions for Study (pp. 526-528). 1. See p. 526, Everyday Biology. Pupils may suggest many other methods of prevention. 2. Because that is the way muscles naturally act in breathing, and artificial respiration is carried on merely to stimulate natural respiration. 3. In cases of fainting place the patient with his head lower than the rest of the body. For small cuts sterilize the wound and put a bandage over it to keep out dirt. Use a tourniquet to stop bleeding from deep cuts, which should then be dressed by a physician. Bruises should be treated with alternate applications of hot and cold water.

Questions for Study (pp. 528-535). 1. The answers will vary with the community, but probably such ones as the following will be named: City water supply, sewage disposal facilities, garbage collection service, city board of health, county physician or county nurse, state board of health. (It will be valuable civic training to get pupils to report on and to discuss the activities of the various public agencies which contribute to the maintenance of community health.) 2. Some adulterants are dangerous to health; all mislead one as to the values of the food he is using; all are dishonest, in that cheap materials are sold at a rate which would be fair for the genuine article. 3. The physician's prescription is designed to fit the particular case. The patent medicine cannot be so constituted that it could benefit the wide variety of ills for which it might be taken. Furthermore, without a physician's diagnosis one cannot be sure he has the disease he thinks he has. 4. The answers to this question will vary widely. Probably no one set of rules is better than any other. The chief value to the student lies in formulating those which seem to apply to his own life. 5. Regulate more carefully the sale of patent medicines containing drugs.

Questions for Study (pp. 542-547). 1. The theory of special creation, that is, that living things suddenly appeared exactly as we now see them; the theory of spontaneous generation; the theory that living things can be produced only by similar living things. 2. Number 33. 3. Redi proved that fly maggots would develop only in meat to which adult flies had access. Pasteur showed that if dust from the air were excluded from flasks of sterilized broth the broth would not spoil, because there would be no living microorganisms present. Tyndall devised apparatus which would remove the dust from the air, permitting dust-free air to reach the infusions.

Questions for Study (pp. 548-562). 1. Vegetative reproduction, asexual-spore reproduction, fission, budding. 2. An organism which is produced by fission contains half of the matter of the parent organism and therefore never dies of old age. 3. Amoeba: fission, asexual-spore formation. Bread mold: budding, spore formation. Hydra: budding, fission, regeneration. Sponge: budding, regeneration from cuttings. 4. No. This kind of spore formation is not true reproduction, because no new individual results. 5. Similarities: Both are asexual methods of reproduction; both result in new individuals; both are characteristic of simple organisms. Differences: Fission results in two organisms of the same size, while budding produces one smaller organism from a larger one; in fission there is no parent, but in budding the larger organism is the parent and is older. 6. Similarities: Both are asexual methods; each produces cells of about equal size. Differences: In fission only two cells result, while in asexual-spore formation many small cells result. 7. Regeneration. It is an artificial method of dividing the animal, instead of a natural one. 8. That the claw had been broken off or injured and that a new claw was regenerating. 9. The cambium. 10. He can be certain that the graft will produce the variety he desires. Also some plants (as seedless oranges) do not grow from seed (except by chance variations in this case).

Exercise on a Biological Principle, p. 171. If a hydra is cut into pieces, each piece can regenerate an entire animal. But if a dog loses a leg, it cannot grow a new one.

EXPERIMENT 96. Reproduction by Conjugation

In conjugation the cell materials pass from the cells of one filament to those of an adjoining filament, so that the spores are all formed in the same filament and the other is left empty.

Questions for Study (pp. 563-565). 1. An asexual spore can grow to produce another organism of its kind. Sex cells cannot develop independently, but two such cells (usually a male gamete and a female gamete) must unite before further growth can occur. 2. When a cell of Spirogyra divides by fission, two new cells are formed; when conjugation occurs, two cells unite to form one. 3. Paramecia can reproduce by fission. Earthworms cannot reproduce normally except by eggs fertilized by sperms from another earthworm. 4. Similarities: Two individuals are involved in the conjugation in each case. Differences: In Spirogyra the contents of one cell unite with those of another, forming one spore. In Paramecium there is an exchange of nuclear materials, and then the two individuals separate.

Questions for Study (pp. 566-570). The pollen grain germinates, producing the pollen tube. This grows down through the style. During this time the pollen nucleus divides, finally forming two male gametes. When the pollen tube reaches the ovule, it enters through a small opening (the micropyle). The male gametes are released through the end of the pollen tube and enter the embryo sac in the ovule. One of the male gametes unites with — that is, fertilizes — the egg cell, or female gamete, found there. The fertilized egg cell grows by cell division to form the embryo.

Questions for Study (pp. 570-572). 1. Reproduce sexually but without special organs: Paramecium, Spirogyra, Ulothrix. 2. Hermaphroditic: earthworm, hydra, some snails, tapeworm. 3. Organisms with separate sexes: moss, cottonwood tree, willow, starfish, insect.

Questions for Study (pp. 573-578). 1. The eggs and the young are not cared for, and many are eaten by enemies. Fertilization too is a matter of chance, dependent on wind or water. 2. An embryo plant develops for a time after fertilization, and then passes through a resting stage in the seed during winter. A bird egg develops but little until the egg is laid and incubated. A mammal egg develops without pause from the time of fertilization. 3. Fertilized egg, two-celled stage, four-celled, eight-celled, sixteen-celled, thirty-two-celled stages, blastula, gastrula, three-layered embryo. 4. By being embedded in the cells of the parent body, by flower or seed structures, by shells or gelatinous coverings, by developing within the body of the mother. 5. By insuring that the embryos are not so readily destroyed by enemies; by permitting the embryo to be fairly well developed before it is set free.

EXPERIMENT 99. Moss

A moss leaf has no veins. The rootlike rhizoids are not true roots and do not reach far into the soil.

EXPERIMENT 100. Fern

Fern sporangia open violently, as if the thickened wall were a taut spring, scattering the spores in all directions.

Questions for Study (pp. 578-581). 1. The leafy moss plants are the gametophytes, or sexual generation. At the tips of leafy plants the sex organs (archegonia and antheridia) are produced. In them, gametes develop. The male gametes swim in films of moisture on the leaves, enter the female sex organs, and fertilize the female gametes. The fertilized egg grows to produce a stalk bearing a sporangium. This is the sporophyte, or asexual generation. The spores produced in the sporangium germinate to produce leafy plants again.

Questions for Study (pp. 581-590). 1. Migration enables an animal to escape unfavorable conditions; it may enable animals to breed in environments favorable to the young. 2. Hibernation enables animals to remain dormant during the winter, when they cannot secure new supplies of energy and when they would be liable to freeze. 3. The lists will vary with the pupil's knowledge. See Everyday Biology, pp. 583-586.

Exercise on a Scientific Principle, p.183. Such statements as this may be given: A newly hatched fish can swin about and secure its own food, while a newly born kitten cannot see, cannot run about, and is dependent on its mother for food.

Questions for Study (pp. 591-598). 1. Leaves may differ in size, margins, length, width, color, etc. Ears of corn may differ in length, number of grains, size of grains, color, weight, etc. Children of the same family may differ in height, color of eyes and hair, shape of face, dispositions, etc. 2. If the individual had descendants who possessed the same character, he would be a mutant. If the character was not inherited, he would be called a freak. 3. A hydrid is the offspring of two individuals distinctly unlike in one or more characters. 4. By crossbreeding. Grafting would ensure the continuation of a chosen variety. The offspring of crossbreeding would inherit qualities from both the types of apple used, and would probably be like neither.

Class Exercise. Variation. In the graph shown, the tallest pupil is 5 feet, eleven inches.

Study Exercise. Mendel's Laws (pp. 603-607). 1. All the offspring will be black hybrids. In these offspring, some of the reproductive cells will have genes for black, and some for white.

2. If two hydrids are crossed, the offspring will be in the ratio of three black to one white. One of the black offspring will be purebred, and the other two will be hybrids.

3. The F_1 generation will be hybrids with rough coats. The F_2 generation will be in the ratio of three rough coated guinea pigs to one smooth coated guinea pig.

4. All the F_1 generation will have rough black coats because rough and black are dominant characters.

The characters of the F_2 generation appear in the Punnett square, thus:

	RB	Rw	sB	sw
RB	RRBB	RRBw	RsBB	RsBw
RW	RRBw	RRww	RsBw	Rsww
sB	RsBB	RsBw	ssBB	ssBw
sw	RsBw	Rsww	ssBw	ssww

Of these offspring, 9 have rough black coats, 3 have black smooth coats, 3 have white rough coats, and one has a white smooth coat. The ones which are different from either the parent or the F_1 generation are those with black smooth coats, and those with white rough coats.

The diagram of imaginary animals will test whether or not pupils understand how to work out problems of Mendelian inheritance. They should proceed something like this: Let c stand for curly tail, B for bushy tail, S for square head, and r for round head. (They may use any symbols they wish. The capital letters indicate dominant characters.) The F_1 generation are hybrids showing the dominant character. Their reproductive cells will carry not only these dominant characters but also the hidden recessives. Therefore reproductive cells may consist of any of these combinations: cS, cr, BS, Br. (If pupils have difficulty knowing what to combine, point out that cB, for example, is not a valid combination, since both indicate the nature of the tail, and the nature of the head is omitted entirely. The animals would be without heads if the reproductive cells did not carry genes for that character.) Then the square will look like the one below. (The order of the letters may vary in any fashion, but the results will all be the same.)

	cS	cr	BS	Br
cS	ccSS	ccSr	cBSS	cBSr
cr	ccSr	ccrr	cBSr	cBrr
BS	cBSS	BcSr	BBSS	BBSr
Br	cBrS	Bcrr	BBSr	BBrr

The characters of the animal drawn in each space will of course be determined by interpreting the symbols: ccSS and ccSr, for example, are curly tailed, with square heads, while cBrr is bushy tailed, with a round head, etc.

Questions for Study (pp. 598-608). 1. Because each new cell contains half of each chromosome of the parent cell. 2. Genes make up chromosomes. They are the true bearers of hereditary characters. 3. The drawing will show three chromosomes in one cell and three in the other. 4. The law of dominance is illustrated by the fact that the offspring of purebred black guinea pigs and pure white ones are black. The law of segregation is shown in the F_2 generation where white guinea pigs may be produced from black hybred parents, showing that the characters black and white did not combine, nor did the white become lost, but was carried in the reproductive cells and could become sorted out, or segregated in the F_2 generation. The law of segregation is clearly shown in problem 4, on page 187.

EXPERIMENT 102. Practical Applications of the Laws of Inheritance

Four children of marriage (1) have normal intelligence, but one of these died in infancy and one was tubercular and alcoholic. Two children of marriage (2) were apparently normal, but these died in infancy. One hundred per cent of the others were feeble-minded. All children of marriage (3) were normal; none were abnormal. None of the children of marriage (4) were known to be normal, and the eight stillbirths show that the stock was not healthy. The evidence indicates that if one parent is feeble-minded some of the children will almost certainly be, as in marriage (1). Marriage (2) indicates that if both parents are feeble-minded most of the children will be. That alcoholism is likely to prevent parents having normal children is shown by marriage (4) where eight were born dead, and the one surviving was feeble-minded. An apparently normal person may transmit genes of feeble-mindedness to the next generation as shown in marriage (4) where the man was the son of a feeble-minded woman. One should know or know about the parents and, if possible, the grandparents, in order to know of any undesirable hereditary characters.

Questions for Study (pp. 609-616). 1. He would examine a field in which some smut appeared, for ears that were not attacked by the parasite. Seeds from these ears would be planted the following year, and again ears that did not develop smut would be selected for seed. 2. He would select a herd bull that had as many as possible of the characteristics he wished to develop in his herd. From the calves produced he would select for breeding purposes those that displayed some of the desired characters. 3. A pedigree is a written record which includes facts concerning ancestry and particularly concerning those traits which are considered desirable in a given breed.

Questions for Study (pp. 617-623). 1. Fossils consist of bones, shells, or other hard parts; imprints on clay or shale; petrified structures; entire organisms preserved in amber or in ice. 2. Evidence supplied by fossils; by geological strata; by the fact that embryos of higher animals look much alike, indicating origin from similar forms; by the fact that many higher animals have homologous structures; by the fact that higher animals retain vestigial organs, which were probably useful organs in ancestral forms; by the fact that within the memory of man many types of plants and animals have changed markedly.

TEACHERS' KEY TO THE TESTS FOR EVERYDAY BIOLOGY

TEST ON UNIT I. Part I

1. the sun. 2. Change man to animals. 3. green plants. 4. transformed.
5. parasite. 6. dependent. 7. more. 8. a; limited. 9. an enemy.
10. adaptation. 11. (4). 12. decrease. 13. man. 14. (5). 15. (1).
16. (3). 17. (3). 18. (3). 19. man. 20. weaker. 21. important.
22. Right. 23. (5). 24. No. 25. symbiosis. 26. protoplasm.
27. respiration. 28. organism. 29. (2). 30. cells. 31. (1).
32. independent. 33. Change a wall to protoplasm. 34. (2). 35. Right.
36. food. 37. Right. 38. inorganic. 39. chemical. 40. Right.
41. division of labor. 42. (2). 43. (2). 44. osmosis. 45. green plants.
46. (4). 47. (1). 48. (3). 49. Right. 50. Change density to concentration
in both cases.

TEST ON UNIT I. Part II

1. (a) tropical. (b): (1) R; (2) R; (3) W; (4) R; (5) R. Best reason: (5).
Score: 7.

2. (a) 1. (b): (1) R; (2) R; (3) W; (4) R; (5) W; (6) R. Best reason: (4).
Score: 8.

3. (a) some. (b): (1) R; (2) W; (3) R; (4) R; (5) R. Best reason: (3).
Score: 7.

4. (a) parasite. (b): (1) W; (2) R; (3) W; (4) W; (5) W; (6) W. Best
reason: (2). Score: 8.

5. (a) in the sea. (b): (1) W; (2) W; (3) W; (4) R; (5) W; (6) U. Best
reason: (4). Score: 8.

6. (1), (4), (6); (15). Score: 12.

Score on Part II: 50.

TEST ON UNIT II. Part I

1. chlorophyll. 2. no. 3. deciduous. 4. Right. 5. oxygen. 6. some.
7. (3). 8. (11). 9. (1). 10. (8). 11. (2). 12. (7). 13. (5).
14. (6). 15. greater. 16. (1). 17. (4). 18. vein or fibrovascular bundle.
19. (2). 20. Right. 21. some. 22. Change increase to stop. 23. sugar.
24. (2). 25. more than. 26. impossible; no. 27. (3). 28. (1).
29. dicot. 30. roots; leaves. 31. seed. 32. (4). 33. mixed. 34. xylem.
35. more. 36. die soon. 37. (4). 38. (4). 39. begin to die. 40. Right.
41. always. 42. pith ray. 43. monocot. 44. (5). 45. (3). 46. (1).
47. (2). 48. greater. 49. (1). 50. (1).

TEST ON UNIT II. Part II

1. (a) Right. (b): (1) R; (2) R; (3) R; (4) W; (5) W; (6) W. Best reason: (3).
Score: 8.

2. (a) unsuccessful. (b): (1) W; (2) R; (3) W; (4) W; (5) W; (6) W; (7) R. Best reason: (2).
Score: 9.

3. (a) smaller. (b): (1) W; (2) W; (3) W; (4) R; (5) U; (6) R. Best reason: (4).
Score: 8.

4. (a) better. (b): (1) W; (2) R; (3) W; (4) W; (5) W; (6) R. Best reason: (2).
Score: 8.

5. (a) Right. (b): (1) W; (2) R; (3) W; (4) W; (5) R; (6) W; (7) W. Best reason: (2).
Score: 9.

6. (a) Right. (b): (1) W; (2) W; (3) W; (4) R; (5) W; (6) W. Best reason: (4).
Score: 8.

Score on Part II: 50.

TEST ON UNIT III. Part I

1. (3). 2. Change larger to smaller or smaller to larger. 3. no. 4. genus; species. 5. bacteria. 6. algae. 7. (1). 8. (3). 9. Right. 10. (3). 11. Right. 12. (2). 13. Right. 14. (4). 15. tapeworm, or liver fluke. 16. sponges (or Porifera). 17. Right. 18. No. 19. flatworms. 20. much, or considerable. 21. an insect, or arthropod. 22. tapeworm. 23. Change places of bacteria and dogs. 24. (5). 25. (1). 26. (2). 27. earthworm. 28. Change more to less in one case or the other. 29. Right. 30. (2). 31. no. 32. (3). 33. (5). 34. larval. 35. Right. 36. 6, 2, 4, 5, 3, 1. 37. complete. 38. reptile. 39. reptiles. 40. animals. 41. (2). 42. (2). 43. (2). 44. (3). 45. may, or sometimes, or often. 46. ventral. 47. never. 48-49. (5) and (7). 50. Most.

TEST ON UNIT III. Part II

1. (2); (4).
Score: 6.

2. (6).
Score: 4.

3. (a) exoskeleton. (b): (1) W; (2) W; (3) R; (4) W; (5) W. Best answer: (3).
Score: 7.

4. (a) clam. (b): (1) W; (2) R; (3) W; (4) W; (5) W; (6) R; (7) R. Best answer: (2).
Score: 9.

5. (a) oxygen. (b): (1) R; (2) R or U; (3) R; (4) R; (5) R; (6) R; (7) W. Best answer: (5).
Score: 9.

6. (a) a mammal. (b): (1) R; (2) R; (3) R; (4) R; (5) R; (6) R; (7) W. Best answer: (5).
Score: 9.

7. (3) and (4).
Score: 6.

Score on Part II: 50.

TEST ON UNIT IV. Part I

1. more. 2. Right. 3. bacteria. 4. nitrogen. 5. leguminous. 6. (3). 7. considerable, or much. 8. Right. 9. Right. 10. Lady bugs, or lady bird beetles. 11. parasites. 12. Little, or no. 13. no. 14. (1). 15. Change pupal to larval. 16. one host. 17. Right. 18. lowest. 19. Change places of tapeworm and hookworm. 20. Right. 21. Right. 22. sometimes (or often) unsuitable. 23. important. 24. more. 25. insects. 26. Right. 27. parasites. 28. more. 29. Many. 30. Change places of benefit and harm. 31. feeding. 32. many. 33. hunters. 34. Insect-eating. 35. rat. 36. crustacean, or arthropod. 37. mountainous. 38. (1). 39. (7). 40. (4). 41. (6). 42. (5). 43. (3). 44. (2). 45. Right. 46. more. 47. crop rotation. 48. prevents. 49. around. 50. (1).

TEST ON UNIT IV. Part II

1. (a) much. (b): (1) W; (2) R; (3) W; (4) R; (5) R; (6) R; (7) R; (8) W. Best reason: (7). Score: 10.

2. Check (3), (7), and (10). Score: 15.

3. (a) greater. (b): (1) R; (2) R; (3) W; (4) W; (5) W; (6) R. Best reason: (1). Score: 8.

4. (a) Right. (b): (1) R; (2) W; (3) R; (4) W; (5) W; (6) W or U. Best reason: (1). Score: 8.

5. (a) may often. (b): (1) U; (2) W; (3) W; (4) R; (5) R; (6) W. Best reason: (4). Score: 9.

Score on Part II: 50.

EXAMINATION ON UNITS I-IV. Part I

1. different from. 2. bottom; food. 3. (3). 4. vertebrae. 5. leaves; transpiration. 6. ancient. 7. No. 8. Dicot, or woody. 9. protective resemblance. 10. no. 11. Right. 12. (2). 13. smaller. 14. oxygen. 15. adaptation, or resemblance. 16. (2). 17. annelids, or the earthworm group. 18. (5). 19. (4). 20. Right. 21. carbon dioxide. 22. photosynthesis. 23. Right. 24. light. 25. symbiosis. 26. photosynthesis. 27. (5). 28. less. 29. sponges. 30. tissue. 31. (1) and (7). 32. slow. 33. transpiration. 34. an organ. 35. (5). 36. cells. 37. green. 38. parasite; cedar. 39. existence, or survival. 40. (2). 41. photosynthesis. 42. (4). 43. transformed. 44. (6). 45. Right. 46. (2). 47. dependent. 48. (2). 49. (4). 50. (2). 51. organic. 52. osmosis. 53. Right. 54. saprophyte. 55. disturbs. 56. Change places of chloroplasts and cells. 57-83. a: 4, 7; b: 6, 7; c: 6; d: 3, 4; e: 3, 4; f: 2, 6, 7; g: 1, 6; h: 1, 6; i: 1, 2, 6, 7; j: 1, 6; k: 2, 5, 6; l: 6, 7. 84-100. a: 2, 3; b: 2, 3; c: 2, 3; d: 1; e: 1; f: 1; g: 1, 4, 5; h: 1, 3, 4, 5, 6.

EXAMINATION ON UNITS I-IV. Part II

1. a. decrease. (b): (1) W; (2) W; (3) U; (4) R; (5) W; (6) W; (7) W; (8) R. Best reason: (4). Score: 10.

2. (7). 3. (4), (11), (12). Score: 9. 4. (11); sunlight and darkness. Score: 6. 5. (5); (11); (16). Score: 15. 6. b: (1) U; (2) R; (3) R; (4) U; (5) R. Best reason: (2). Score: 6.

Score on Part II: 50.

TEST FOR UNIT V. Part I

1. (4). 2. holding. 3. No. 4. no. 5. (7). 6. (8). 7. (3). 8. (6). 9. (5). 10. (1). 11. (4). 12. (10). 13. (6). 14. (5). 15. (1). 16. (3). 17. (2). 18. (7). 19. digestion. 20. osmosis. 21. energy. 22. impossible. 23. higher; all. 24. (4). 25. (7). 26. (4). 27. (2). 28. (8). 29. (1). 30. (6). 31. (5). 32. none. 33. (4). 34. (1). 35. birds, or mammals. 36. Change capillaries to arteries. 37. Right. 38. white. 39. assimilation. 40. stomata. 41. nitrogen, or carbon dioxide. 42. (4). 43. hormones. 44. diabetes. 45. Change places of insect and mammal. 46. pituitary. 47. oxidation. 48. absorption. 49. (2). 50. respiratory.

TEST FOR UNIT V. Part II

1. (a) (2). (b): (1) R; (2) U; (3) R; (4) R; (5) R; (6) R; (7) R. Best reason: (4). Score: 9.

2. (a) Change but not to and also. (b): (1) R; (2) R; (3) R; (4) R; (5) R; (6) W; (7) W. Best reason: (1). Score: 9.

3. (a) abdomen. (b): (1) U; (2) R; (3) W; (4) W; (5) W; (6) R. Best reason: (2). Score: 8.

4. (a) Right. (b): (1) R; (2) W; (3) W; (4) R; (5) W; (6) R. Best reason: (4). Score: 8.

5. (a) impossible. (b): (1) W; (2) R; (3) W; (4) R; (5) U; (6) R. Best reason: (4). Score: 8.

6. (a) Right. (b): (1) U; (2) R; (3) R; (4) R; (5) U; (6) W. Best reason: (4). Score: 8.

Score on Part II: 50.

TEST ON UNIT VI. Part I

1. All. 2. Right. 3. no. 4. (2). 5. Sensory. 6. Motor. 7. irritability. 8. stimulus. 9. Right. 10. (3). 11. head. 12. more. 13. ganglion. 14. more. 15. medulla. 16. smaller. 17. smaller; less. 18. Right. 19. few. 20. much. 21. impossible. 22. never. 23. tropism. 24. Change higher to lower, or more to less. 25. habit. 26. less. 27. complex, or well developed. 28. a man. 29. (1). 30. well. 31. small. 32. touch, or contact. 33. (5). 34. Right. 35. usually. 36. dissolve. 37. able. 38. Right. 39. (3). 40. Change places of lens and compound. 41. All; lens. 42. Right. 43. abdomen. 44. impossible. 45. ear. 46. iris. 47. Change seldom to never, and six to two. 48. Right. 49. Right. 50. Change places of lower brain centers and cerebrum.

TEST FOR UNIT VI. Part II

1. (a) All. (b): (1) R; (2) R; (3) R; (4) R; (5) R; (6) R. Best reason: (4).
Score: 8.

2. (a) Right. (b): (1) R; (2) R; (3) R; (4) R; (5) R; (6) W. Best reason: (5).
Score: 8.

3. (a) new. (b): (1) W; (2) R; (3) W; (4) R; (5) W. Best reason: (2).
Score: 7.

4. (2), (4), (6), (9), (12).
Score: 20.

5. (a) less. (b): (1) R; (2) R; (3) W; (4) W; (5) W. Best reason: (1).
Score: 7.

Score on Part II: 50.

TEST ON UNIT VII. Part I

1. Right. 2. (3). 3. Change bacteria to mold. 4. Many. 5. (2).
6. possible. 7. Right. 8. antitoxins. 9. white. 10. increase.
11. antitoxin. 12. toxoid, or toxin-antitoxin. 13. mental. 14. (3).
15. less. 16. No. 17. carried. 18. tuberculosis. 19. sometimes.
20. parasitism. 21. never. 22. considerable. 23. sometimes. 24. (5).
25. (2). 26. (4). 27. (1). 28. (8). 29. (3). 30. (1). 31. shorter.
32. water. 33. never. 34. false. 35. Right. 36. considerable.
37. brushing. 38. Right. 39. little, or no. 40. impossible. 41. rest.
42. noncommunicable, or some, or organic, or similar word. 43. Right.
44. Right. 45. opium, or drugs. 46. marijuana. 47. never; any. 48. (4).
49. Right. 50. young.

TEST ON UNIT VII. Part II

1. (a) Right. (b): (1) W; (2) R; (3) R; (4) R; (5) W or U; (6) W; (7) W. Best reason: (3).
Score: 9.

2. (a) no. (b): (1) R; (2) W; (3) W; (4) W; (5) W; (6) W. Best reason: (1).
Score: 8.

3. (a) never. (b): (1) W; (2) W; (3) W; (4) W; (5) R; (6) R; (7) W. Best reason: (5).
Score: 9.

4. Check (4), (5), (6), (7), (8), (9), (10), (11). Number in order (5), (7), (9), and (10).
Score: 24.

Score on Part II: 50.

TEST ON UNIT VIII. Part I

1. Right. 2. partly. 3. several men or many men. 4. Sexual. 5. never.
6. fission. 7. (3). 8. Some, several, or many; have. 9. Both; and.
10. Many; are. 11. regeneration. 12. Right. 13. regeneration.
14. fertilization. 15. (1). 16. Right. 17. Right. 18. Right. 19. Right.
20. Right. 21. much, great, or considerable. 22. (2), (4), (5), (1), (3).
23. Right. 24. (4). 25. Change places of asexual and sexual. 26. decrease.

27. insects. 28. No. 29. Right. 30. dominant. 31. no. 32. an instinct.
33. Right. 34. smaller. 35. mutant. 36. freak. 37. hybrid. 38. Change
places of heredity and environment. 39. Change places of chromosomes and genes.
40. dominant. 41. all. 42. three fourths. 43. all. 44. and also.
45. and also. 46. Change places of small and large. 47. much. 48. less.
49. cross-breeding or cross-fertilization. 50. embryo.

TEST ON UNIT VIII. Part II

1. (a) (1). (b): (1) R; (2) W; (3) R; (4) R; (5) W; (6) W. Best reason: (4). Score: 8.

2. (a) Right. (b): (1) R; (2) R; (3) R; (4) R; (5) R; (6) W. Best reason: (2). Score: 8.

3. (a) (5). (b): (1) W; (2) R; (3) W; (4) W; (5) W. Best reason: (2). Score: 7.

4. (a) old. (b): (1) W; (2) R; (3) R; (4) R; (5) R. Best reason: (3). Score: 7.

5. Check (3) and (5). Marked R: (6), (8), (10). Reason checked: (6). Score: 12.

6. (2), (5), (8), (10). Score: 8.

Score on Part II:50.

EXAMINATION ON UNITS V-VIII

1. regeneration. 2. cerebrum. 3. all. 4. neurons. 5. grandparent.
6. some, considerable, or much. 7. None. 8. sympathetic or autonomic.
9. crop rotation. 10. one half. 11. sponge. 12. no. 13. (10). 14. (12).
15. (7). 16. (9). 17. (4). 18. (5). 19. (2). 20. (3). 21. two;
gametes. 22. (3). 23. never (or so very infrequently as to be beyond the
pupil's knowledge.) 24. antitoxins. 25. Right. 26. (1). 27. No.
28. cerebrum. 29. pistil. 30. stamens. 31. Right. 32. young. 33. (2).
34. positive. 35. cambium; cambium. 36. (5) or (2). 37. one half.
38. germ, or microbe. 39. Change swamp to man. 40. variations.
41. irritable. 42. impossible. 43. (4). 44. no; seldom. 45. never; any.
46. harmful. 47. impossible. 48. (2). 49. (5). 50. (5). 51. (3).
52. (4). 53. (3). 54. excretion. 55. (2). 56. (1). 57. portal.
58. breathing. 59. (1). 60. urea. 61. assimilation. 62. transformed.
63. small intestine. 64. Right. 65. Right. 66. mosquito. 67. X-ray.
68. (1). 69. water. 70. (4). 71. (5). 72. transformed. 73. circulatory.
74. all. 75. pancreatic juice. 76. insulin. 77. protozoan. 78. Right.
79. neither; nor. 80. English walnuts. 81. (5). 82. (2). 83. D. 84. S.
85. S. 86. S. 87. D. 88. S. 89. D. 90. S. 91. S. 92. D. 93. D.
94. S. 95. D. 96. S. 97. D. 98. S. 99. D. 100. S.

TEST ON STRUCTURE AND FUNCTIONS

I. 1. Food vacuoles or food particles. 2. Nucleus. 3. Contractile vacuole. 4. Pseudopodia or false feet. Simple eye or ocellus. 6. Compound eye. 7. Antennae. 8. Prothorax, or thorax. 9. Ear or tympanum. 10. Jumping legs. 11. Ovipositor. 12. Spiracles. 13. Pharynx. 14. Heart. 15. Liver. 16. Gall bladder. 17. Small intestine. 18. Spleen. 19. Large intestine. 20. Lung. 21. Stomach. 22. Kidneys. 23. Bladder. 24. Abdomen. 25. Cephalithorax or head thorax. 26. Stomach. 27. Esophagus. 28. Antenna. 29. Chela, pincer, or large claw. 30. Heart. 31. Nerve cord. 32. Pectoral fin. 33. Caudal fin. 34. Dorsal fin. 35. Operculum or gill cover. 36. Gizzard. 37. Hearts. 38. Esophagus. 39. Crop. 40. Intestine.

II. Digestion: A, 1; B, —; C, 13, 15, 16, 17, 19, 21; D, 26, 27; E, 36, 38, 39, 40. Respiration: A, —; B, 12; C, 20; D, —; E, —. Reproduction: A, —; B, 11; C, —; D, —; E, —. Excretion: A, 3; B, —; C, 16, 19, 20, 22, 23; D, —; E, —. Circulation: A, —; B, —; C, 14; D, 30; E, 37. Irritability: A, 4; B, 5, 6, 7, 9; C, —; D, 28, 31; E, —. Locomotion: A, 4; B, 10; C, —; D, —; E, —.

III. 41. Upper epidermis. 42. Palisade tissue. 43. Chloroplasts. 44. Spongy layer. 45. Vein or vascular bundle. 46. Stomata. 47. Guard cell. 48. Pith. 49. Epidermis. 50. Phloem. 51. Xylem. 52. Cambium. 53. Epidermis. 54. Cortex. 55. Fibrovascular bundle. 56. Cell wall. 57. Cytoplasm. 58. Nucleus. 59. Chromosomes. 60. Protoplasm. 61. Stigma. 62. Stamen. 63. Ovules. 64. Sepal. 65. Pistil. 66. Petal. 67. Anther. 68. Hypocotyl. 69. Plumule. 70. Cotyledon.

IV. 1. 69. 2. 58. 3. 59. 4. 52. 5. 47. 6. 70. 7, 8. 45, 55, (or 50, 51). 9, 10, 11. 50, 51, 52. 12, 13, 14. 68, 69, 70. 15. 46. 16. 67. 17. 61. 18. 43. 19. 42. 20. 68. 21. 63. 22. 46. 23. 67. 24. 63.

TEST ON BIOLOGICAL PRINCIPLES

1. (11), (5). 2. (10). 3. (2). 4. (9), (8). 5. (1), (3). 6. (8), (6). 7. (5), (11), (3). 8. (4). 9. (9), (6). 10. (5). 11. (7). 12. (8), (10). 13. (3), (8), (9). 14. (8), (1). 15. (8). 16. (10). 17. (9), (1). 18. (7), (6). 19. (2). 20. (5), (3). 21. (11). 22. (10), (11). 23. (8), (5). 24. (2). 25. (12). 26. (3). 27. (13). 28. (7), (11). 29. (1), (6). 30. (11), (9), (13).

TEST ON SCIENTIFIC ATTITUDES

1. 2, 3. 2. 8, 3, 12. 3. 5, 11, 9. 4. 2, 8. 5. 1, 7, 9, 10. 6. 8, 10, 12. 7. 7, 8, 9, 11. 8. 5, 10, 11. 9. 4, 3. 10. 2. 11. 12, 9, 8. 12. 6, 8, 9. 13. 2, 4, 6. 14. 1, 7, 8, 10. 15. (4), (3). 16. (6), (1). 17. (5), (2). 18. (5), (2). 19. (2), (5). 20. (3), (1). 21. (6), (1). 22. (4), (1). 23. (3), (5). 24. (4), (2). 25. (2), (4).

TEST ON SCIENTIFIC METHOD

1. a: (1), (4). b: (4). c: (2). d: (13). e: (13). f: (11). g: (10). h: (6). i: (6), (7). 2. (1). 3. (4). 4. (2). 5. (4). 6. (2). 7. (5). 8. (4). 9. (6). 10. (2), (3), (5), (11). 11. (5). 12. (1).

TEST ON SOCIAL IMPLICATIONS

(This test will be most valuable if it is used as a basis for class discussion, rather than for marking purposes.) 2, 3, 4, 6, 10, 13, and 20. (1) W; (2) R; (3) W; (4) R; (5) U; (6) U; (7) U; (8) U; (9) W; (10) U; (11) R; (12) W; (13) U; (14) W.

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